PRESTRESSING IN A TWO-BAY FRAME WITH PINNED SUPPORTS

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ABSTRACT

While literature discussing the effect of prestressing on continuous beams is available, the analysis of the influence of prestressing on more complicated systems such as multi-bay and multi-storey frames remains insufficiently developed.

The purpose of this work is to develop a simplified design procedure for a one storey two-bay prestressed frame with pinned supports subjected to different cases of loading.

It appears that the analysis of the prestressing as well as the external loading on a multi-bay frame could be made simple using the matrices and the virtual work method.

Practical tables for the evaluations of the statically indeterminate reactions and moments have been developed in this work using the computer.

The influence of prestressing by means of cable with different profiles located in beams and columns has been analysed and recommendations have been developed for tracing the cables in such a manner as to obtain from the prestressing the most desirable stress condition for the given external load.

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NOMENCLATURE

A	Cross-sectional area of beams or columns
b	Width of the cross-section
d	Depth of the cross-section
E	Modulus of elasticity
e	Eccentricity of the cable with respect to the centroidal axis of the member
f	Normal stress on a section
h	Height of the frame
I	Moment of inertia
i	Radius of gyration
K	Ratio between external moment and prestressing moment coefficients
L	Span length
M	Bending moment
Mp	Prestressing moment
M_L	External moment
M_M	Bending moment computed with neglecting the effect of axial deformations caused by the thrust
M_N	Moment component related to the axial deformations caused by the thrust
Mo	Bending moment in the main system
N	Thrust
No	Thrust in the main system
P	Prestressing force
t	Change in the temperature

V	Shearing force
W	Concentrated load
w	Distributed load
X	Indeterminate reaction — parasitic reaction
X_M	Reaction component computed with neglecting the effect of axial deformations caused by the thrust
X_N	Reaction component related to the axial deformations caused by the thrust
y	Ratio of the height h to the span L in the frame
γ	Thermol coefficient
δ	Deformation — displacement of the support

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GENERAL INTRODUCTION

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GENERAL INTRODUCTION

A two-bay frame with pinned supports is a three times statically indeterminate structure.

While the analysis of prestressing in statically determinate structures is relatively simple due to the fact that the line of thrust resulting from the prestressing alone is coinciding with the cable profile, the analysis of statically indeterminate structures is more complicated because it involves secondary moments that result from prestressing, and the line of thrust for most cases is not coinciding with the cable profile. The value of these secondary moments is not negligible and may be an important factor in the design.

The general design principle is the same in case of statically determinate and indeterminate prestressed structures, i.e., the applied prestressing must be of such type and magnitude that when stresses caused by it are super-imposed upon those due to the loads, the resultant stress will be written the specified limits.

In statically determinate structures, the stresses due to prestressing alone are generally combined stresses due to a direct load eccentrically applied. These stresses are computed using the well known relationship for combined stresses

$$f = P/A \pm My/I \tag{1}$$

where $M = P.e$ is the moment acting on the cross section.
The above relationship can be written:

$$f = P/A\ (1 \pm ey/i^2) \tag{1.a}$$

where $i^2 = I/A$.

In statically indeterminate structures, the stresses due to prestressing alone are:

$$f = (P \pm N_1)/A + (P.e \pm M_1)y/I \tag{2}$$

where N_1 is the thrust at that section due to parasitic reactions, i.e., reactions at the supports caused by prestressing alone, and where M_1 is the secondary moment due to these parasitic reactions.

The secondary moments could be helpful or undesirable depending on the loading case and the designer must choose a suitable cable profile for each case of loading. In a continuous frame this choice is difficult due to the large number of unknown but the analysis can be simplified by studying the effect of prestressing different cable profiles as follows:

1. The values of the parasitic reactions and hence of the secondary moments are computed for each cable profile when tentioned by a force P. The factors on which depend those values are determined.

2. The secondary moment is added to the moment P.e and the final moment due to prestressing only is obtained.

3. The bending moment due to dead and live load acting on the frame is computed using the same traditional methods employed in analysing indeterminate structures.

4. Comparing the results of the steps 2 and 3, the suitable cable profile for the required case of Loading can be selected.

Design Factors:

Considering now the continuous frame with pined supports shown in Fig. (1), the different elements involved in the design are:

1. The two spans L_1 and L_2.
2. The height h of the frame.
3. The moment of inertia Io for the Girder and I for the Column.
4. The cross sectional area Ao for the Girder and A for the column.
5. The prestressing force P.
6. The eccentricity e with respect to the centroidal axis.
7. The modulus of elasticity E for the concrete.
8. The dead load D of the frame and the applied live load L.

The effect of each of these elements on the design of the structures will be discussed later.

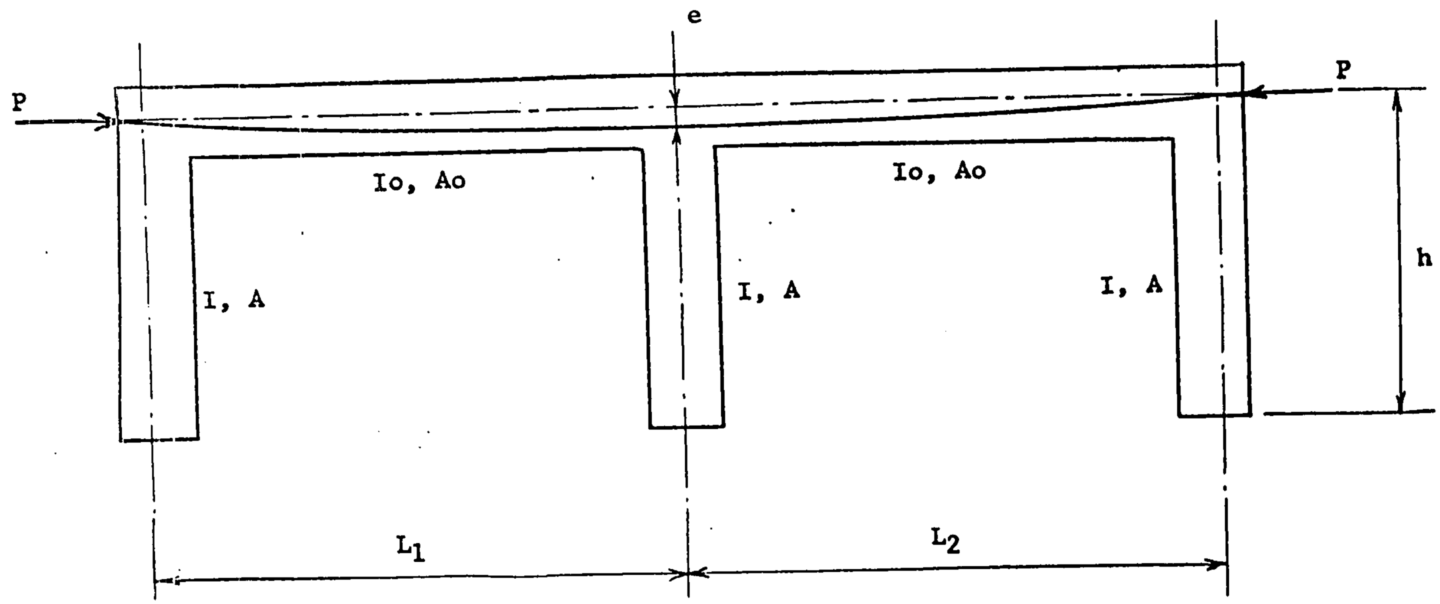

FIG. 1 Design Factors in a Two-Bay Frame
with Pined Supports

Assumptions:

In the analysis of the continuous frame the following assumptions are made:

1. Plane sections remain plane in bending.
2. Within the range of stresses permitted in the design the concrete acts as an elastic material.
3. The effect of friction on the prestressing force is small and can be neglected.
4. The prestressing force P is assumed to have a constant magnitude along the whole length of the member.
5. The eccentricity "e" is very small compared to the span L and the cable profiles are so flat that the tangent at each point along the cable may be considered as normal to the cross section and hence the reaction of the cable on the concrete due to its curvature can be neglected.

In the analysis, the effect of the axial deformation in the members resulting from prestressing will not be neglected assuming that it may be significant in the case of frames.

It is understood that the work "cable" denotes the resultant cable, i.e., the imaginary cable which, in respect of the magnitude and position of the force it exerts, is equivalent to all the cables in the cross-section.

CHAPTER II

ELASTIC ANALYSIS OF PRESTRESSING

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ELASTIC ANALYSIS OF PRESTRESSING

In the two-bay frame a b c d e f with pinned supports, there are six possible reaction components. As the conditions of equilibrium are three, the frame is three times statically indeterminate.

Assuming that before the frame is prestressed, we have removed the support f and replaced the hinge at d by a rollar as shown on Fig. (3). Under prestressing, this system will undergo a horizontal displacement at d and a horizontal as well as a vertical displacement at f.

In order to return the frame to its original position, three reactions X_1, X_2 and X_3 have to be applied as shown in Fig. (3). These reactions are called parasitic and are caused by the prestressing only. Their number is three since the considered frame is three times statically indeterminate. The value of these reactions can be computed by using the method of virtual work as follows:

For the system shown in Fig. (3) a unit horizontal force applied at d will cause a horizontal displacement δ_{11} at that point and a horizontal as well as a vertical displacement δ_{12} and δ_{13} respectively at f. Similarly a unit horizontal force applied at f will cause a horizontal displacement δ_{21} at d equal to δ_{12} (Maxwell theorem)

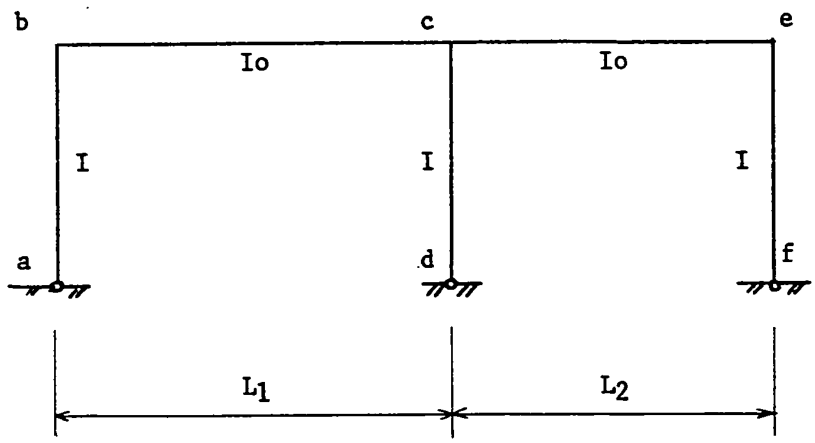


FIG.2 Two-Bay Frame with Pinned Supports

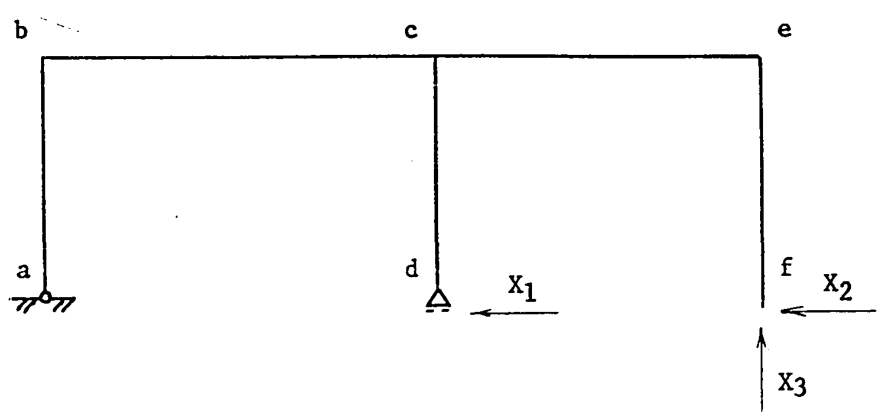


FIG.3 Main System

and a horizontal as well as a vertical displacement δ_{22} and δ_{23} respectively at f. Finally a unit vertical force applied at f will cause a horizontal displacement δ_{31} at d (equal to δ_{13}) and a horizontal as well as a vertical displacement δ_{23} (= δ_{32}) and δ_{33} respectively at f.

To return the frame to its original position, the sum of the displacements caused by the prestressing and by the reactions X_1, X_3 and X_3 at each support must equal zero. Applying this condition at each of d and f we have:

$$\delta_{10} + X_1 \delta_{11} + X_2 \delta_{12} + X_3 \delta_{13} = 0 \qquad (3.a)$$

$$\delta_{20} + X_1 \delta_{21} + X_2 \delta_{22} + X_3 \delta_{23} = 0 \qquad (3.b)$$

$$\delta_{30} + X_1 \delta_{31} + X_2 \delta_{32} + X_3 \delta_{33} \quad 0 \qquad (3.c)$$

By computing the values of the previous displacements and solving the three equations together we get the values of the parasitic reactions X_1, X_2 and X_3.

The three previous equations can also be written on the form of a matrix equation.

$$\begin{bmatrix} \delta_{11} & \delta_{12} & \delta_{13} \\ \delta_{21} & \delta_{22} & \delta_{23} \\ \delta_{31} & \delta_{32} & \delta_{33} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = - \begin{bmatrix} \delta_{10} \\ \delta_{20} \\ \delta_{30} \end{bmatrix} \qquad (4)$$

or $\underline{A}.\underline{X} = \underline{B}$.

The values of the displacements "δ" can be determined by using the method of virtual work. This method is an application of the general energy method in which the external work done is equal to the internal work or strain energy. In this method it is assumed that when the applied loads or moments are removed, the structure will return to its original position, i.e., the structural material is not stressed beyond the elastic limit. It is also assumed that the structural material is linearly elastic and that the work done due to any straining action will be

1/2 Force x displacement

The internal work can be related to the stresses on a differential element due to a normal force N, a moment M and a shear V.

Assume now that the frame on Fig. (4) was subjected to prestressing as shown and that the straining actions related to this prestressing are a thrust No and a moment Mo. The corresponding stresses in a differential length dL will be fNo and fMo respectively.

Now assume that a unit horizontal force X_1 is applied at d and produces a thrust N_1 and a moment M_1. The corresponding strain in the differential length dL will be N_1 and M_1.

The change in the strain energy due to the application of $X_1 = 1$ at d in the differential length dL is

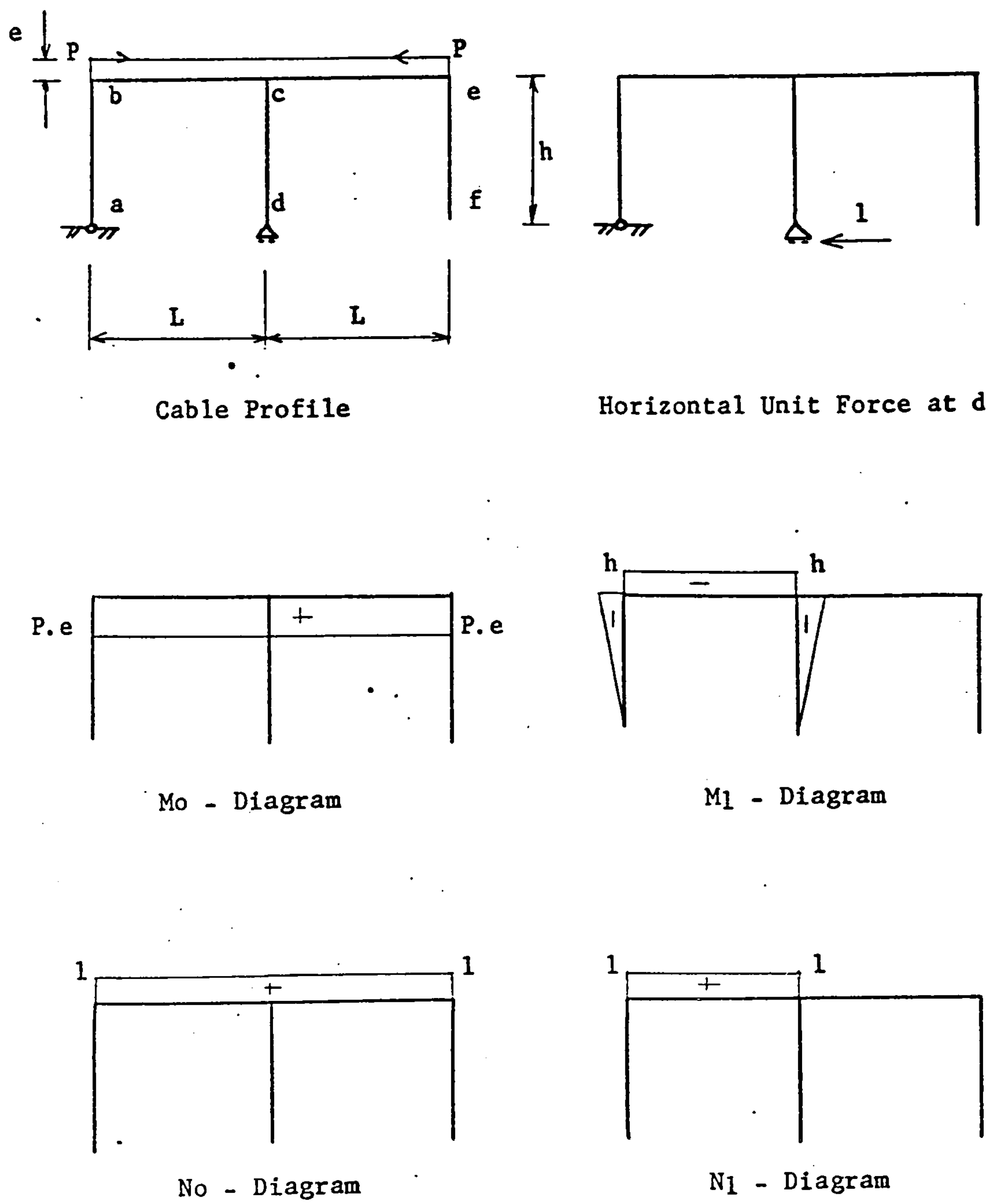


FIG. 4 Elastic Analysis of Prestressing

$$dWs = 1/2\ f_{No}.A \times \mathcal{E}_{N1}dL + 1/2 \times \int_A f_{Mo}dA \times \mathcal{E}_{M1}dL \tag{5}$$

(note that the strain = $\frac{\text{deformation in dL)}}{\text{length dL}}$

but $f_{No} = \frac{No}{A}$

$f_{Mo} = \frac{Mo.y}{I}$

$N1 = f_{N1}/E = \frac{N1}{AE}$

$M1 = f_{M1}/E = \frac{M_1 y}{EI}$

substituting for these values in equation (5):

$$dWs = 1/2\ No\ \frac{N_1 dL}{AE} + 1/2\ \frac{M_1 ModL}{EI^2} \int_A dAy^2$$

but $\int_A dAy^2 = I$

therefore $dWs = 1/2\ \frac{N_1 NodL}{AE} + 1/2\ \frac{M_1 ModL}{EI}$ (5.a)

The change in the strain energy through the whole length will be

$$Ws = 1/2 \int_0^L \frac{N_1 NodL}{AE} + 1/2 \int_0^L \frac{M_1 ModL}{EI} \tag{6}$$

The external work done by the force $X_1 = 1$ through a displacement

$\delta 10$ at support d is:

$$WE = 1/2 \times 1 \times \delta 10 \tag{7}$$

Equating (6) and (7) we have

$$\delta 10 = \int_0^L \frac{N_1 NodL}{AE} + \int_0^L \frac{M_1 ModL}{EI} \tag{8}$$

By using the same analysis as before we can prove that

$$\delta 20 = \int_0^L \frac{N_2 NodL}{AE} + \int_0^L \frac{M_2 ModL}{EI} \tag{9}$$

$$\delta_{30} = \int_0^L \frac{N_3 N_o dL}{AE} + \int_0^L \frac{M_3 M_o dL}{EI} \tag{10}$$

$$\delta_{11} = \int_0^L \frac{N_1^2 dL}{AE} + \int_0^L \frac{M_1^2 dL}{EI} \tag{11}$$

$$\delta_{12} = \int_0^L \frac{N_1 N_2 dL}{AE} + \int_0^L \frac{M_1 M_2 dL}{EI} = \delta_{21} \tag{12}$$

$$\delta_{13} = \int_0^L \frac{N_1 N_3 dL}{AE} + \int_0^L \frac{M_1 M_3 dL}{EI} = \delta_{31} \tag{13}$$

$$\delta_{22} = \int_0^L \frac{N_2^2 dL}{AE} + \int_0^L \frac{M_2^2 dL}{EI} \tag{14}$$

$$\delta_{23} = \int_0^L \frac{N_2 N_3 dL}{AE} + \int_0^L \frac{M_2 M_3 dL}{EI} \tag{15}$$

$$\delta_{33} = \int_0^L \frac{N_3^2 dL}{AE} + \int_0^L \frac{M_3^2 dL}{EI} \tag{16}$$

The moment is considered positive when it produces tension at the bottom fibre, while the thrust is positive when it produces a compression in the member.

By substituting the different displacement values computed above into equations (3a), (3b) and (3c) and solving these equations together we obtain the value of the reactions X_1, X_2 and X_3. The latest are the parasitic reactions caused by the deformation that occurs in the frame due to prestressing only. These parasitic reactions produce a secondary moment that has to be added to the moment caused by the prestressing force and the eccentricity. The result is the final moment in the continuous frame due to prestressing only.

CHAPTER III

PRESTRESSING VALUES FOR DIFFERENT CABLE PROFILES

In this chapter we will consider some different profiles of the tensioned cable and compute the corresponding parasitic reactions and secondary moments. The application of the principle of superposition will be very useful since the superposition of two or more profiles will develop a new cable profile for which the parasitic reactions and the secondary moment are computed always by superposition.

1.a Linear Cable in the Whole Girder Coinciding with the Centroidal Axis

As a preliminary case we consider prestressing when the cable profile is coinciding with the centroidal axis of the member. This case will show the effect of the thrust on the value of the secondary moment.

For simplicity consider the case when the frame has two equal bays and when the areas and moment of inertias of the columns are the same as those of the girder.

The values of the deformations caused by the prestressing and by the unit loads applied at the supports are:

$$\delta_{10} = \int_0^L N_1 N_o dL/AE = PL/AE \text{ (the value of Mo being zero)} \quad (8.a)$$

similarly,

$$\delta_{20} = \int_0^L N_2 N_o dL/AE = 2PL/AE \quad (9.a)$$

$$\delta_{30} = \int_0^L N_3 N_o dL/AE = 0 \quad (10.a)$$

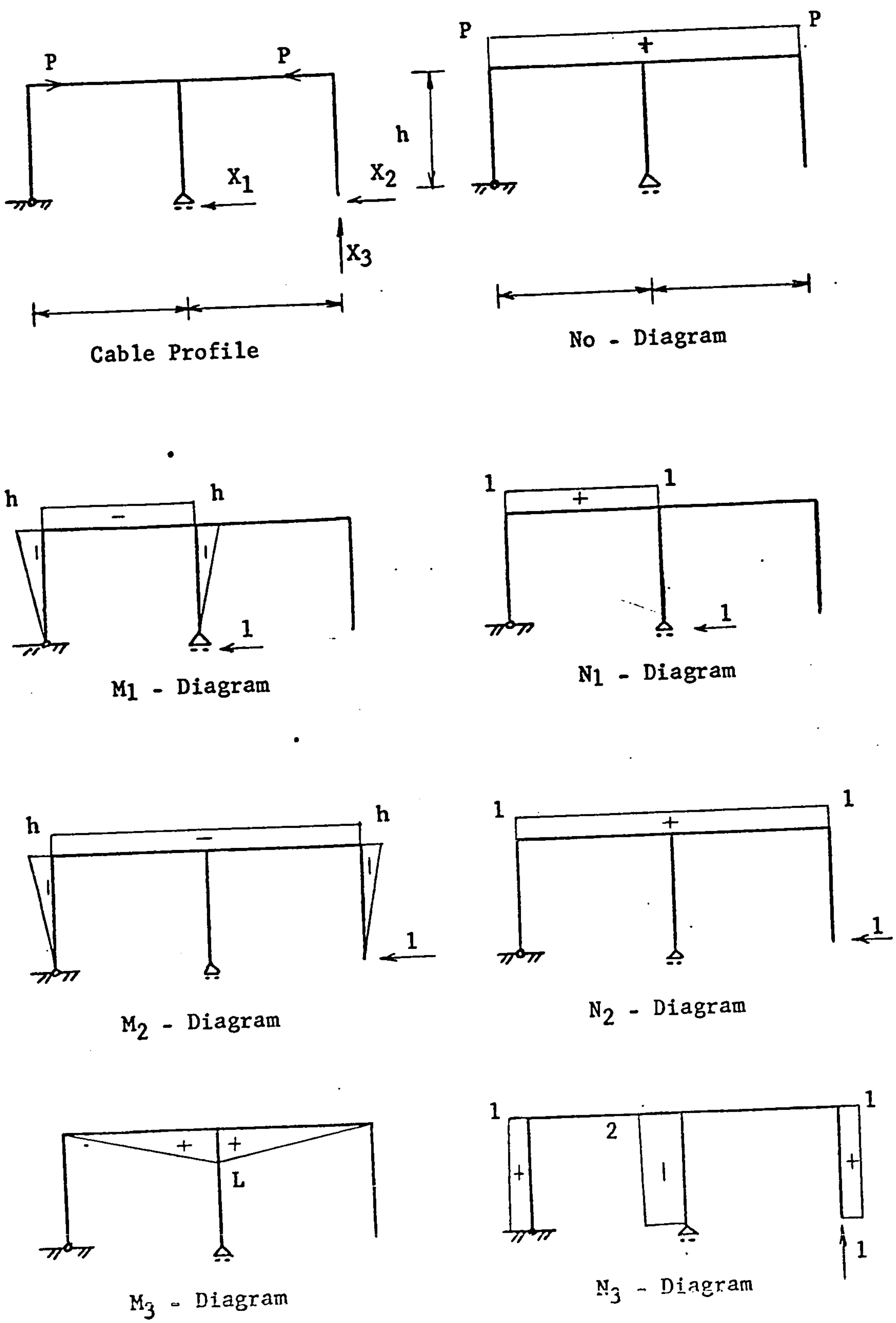


FIG. 5 Linear Cable Coinciding with the Centroidal Axis of the Girder

CHAPTER III

PRESTRESSING VALUES FOR DIFFERENT CABLE PROFILES

$$\delta_{11} = \int_0^L N_1^2\,dL/AE + \int_0^L M_1^2\,dL/EI$$

$$= L/AE + h^2L/EI + 2h^3/3EI \qquad (11.a)$$

$$\delta_{12} = \int_0^L N_1N_2\,dL/AE + \int_0^L M_1M_2\,dL/EI$$

$$= L/AE + h\ L/EI + h\ /3EI = 21 \qquad (12.a)$$

$$\delta_{13} = \int_0^L N_1N_3\,dL/AE + \int_0^L M_1M_3\,dL/EI$$

$$= 0 - hL^2/2I = \delta_{31} \qquad (13.a)$$

$$\delta_{22} = \int_0^L N_2^2\,dL/AE + \int_0 M_2^2\,dL/EI$$

$$= 2L/A + 2h^2L/I + 2h^3/3I \qquad (14.a)$$

$$\delta_{23} = \int_0^L N_2N_3\,dL/AE + \int_0^L M_2M_3\,dL/EI$$

$$= 0 - hL^2/I = \delta_{32} \qquad (15.a)$$

$$\delta_{33} = \int_0^L N_3^2\,dL/AE + \int_0^L M_3^2\,dL/EI$$

$$= 6h/A + 2L^3/3I \qquad (16.a)$$

Substituting for these deflection values in equations $(3)^a$, $(3)^b$ and $(3)^c$ and solving them together we get

$$X_1 = 0 \qquad (17)$$

$$X_2 = -\ PL/A\ \frac{6h/A + 2L^3/3I}{(L/A + h^2L/I + h^3/3I)(6h/A + 2L^3/3I) - h^2L^4/2I^2}$$

for $h/L = y$ and $i = I/A$

$$X_2 = -\ P\left[\frac{6y + 2/3\ (L/i)^2}{6y + (L/i)^2\ (6y^3 + 2y^4 + 2/3) + (L/i)^4\ (1/6y^2 + 2/9y^3)}\right] \qquad (18)$$

Assuming that the ratio between the depth d of the girder and the span L varies between 1/10 to 1/40 and the ratio $h/L = y$ varies between 1/10 to 10. Accordingly the value of $i = d/6$ will vary between L/60 and L/240. Substituting in equation (18) for $L/i = 60$ and for $y = 0.1$, 1 and 10 respectively we get

$$X_2 = -\ 0.08962P \quad \text{for } y = 0.1$$

$$X_2 = -\ 4.74 \times 10 \quad P \quad \text{for } y = 1$$

$$X_2 = -\ 0.771 \times 10 \quad P \quad \text{for } y = 10$$

for a fixed ratio d/L, the value of X decreases with the increase of the ratio h/L.

Consider now the case when $h/d = 40$. Substituting in equation (18) for $L/i = 240$ and for $y = 0.1$ and 1 respectively we get

$$X_2 = -\ 60.95 \times 10 \quad P \quad \text{for } y = 0.1$$

$$X_2 = -\ 29.83 \times 10 \quad P \quad \text{for } y = 1$$

to find out the percentage of error in the value of the parasitic reactions when the effect of the axial deformation in the members caused by the unit force at the supports is neglected, we delete the terms in N_1^2, N_2^2, N_3^2, N_1N_2, N_2N_3 and N_1N_3 in equations (11) to (16). In this case the value of X_2 will be

$$X_2 = -\ P/(L/i) \quad \frac{1}{1/4y + 1/3y} \tag{18.a}$$

Substituting for $L/i = 60$ and for $y = 0.1$ and 1 respectively in equation (18)[a] we get

$$X_2 = -\ 0.098\ P \quad \text{for } y = 0.1$$

$$\text{The percentage of error} = \frac{(98 - 89.62)}{89 - 62} \times 100 = 9.3\%$$

$$X_2 = -\ 4.97 \times 10 \quad P \quad \text{for } y = 1$$

and the percentage of error in X_2 when $y = 1$ and $L/i = 60$

$$= \frac{497 - 474}{474} \times 100$$

$$= 4.85\%$$

Substituting in equation (18a) for $L/i = 240$ and for $y = 0.1$ we get

$$X_2 = - 61.2P \times 10$$

the percentage of error in X_2 when $L/i = 240$ and $y = 0.1$

$$= \frac{61.2 - 60.95}{60.95} \times 100$$

$$= 0.4\%$$

Substituting in equation (18a) for $L/i = 240$ and $y = 1$ we get

$$X_2 = - 30.1P \times 10$$

and the percentage of error in X_2 when $L/i = 240$ and $y = 1$

$$= \frac{30.1 - 29.83}{29.83} \times 100$$

$$= 0.9\%$$

Conclusion:

If the axial deformations in the members of the frame caused by the thrust due to a horizontal unit force applied at the end support are neglected, the values of the reaction X_2 increase in the practical cases of prestressing by an amount varying between 0.4 and 9.3 percent depending on the values of L/i and h/L.

Repeating the same previous analysis in the case of X_3; the exact value is

$$X_3 = - P \left[\frac{y\ (L/i)^2}{6y + (L/i)^2\ (6y^3 + 2y^4 + 2/3) + (L/i)^4\ (1/6y^2 + 2/9y^3)} \right] \tag{19}$$

while the value of X_3 when the effect of the thrust due to the unit reactions is neglected is

$$X_3 = - P/(L/i)^2 \left[\frac{1}{1/6y + 2/9y^2} \right] \tag{19.a}$$

The percentage of error between the two values is

9.3% when $L/i = 60$ and $y = 0.1$

2.67% when $L/i = 60$ and $y = 1$

0.54% when $L/i = 240$ and $y = 0.1$

1.9% when $L/i = 240$ and $y = 1$.

As it is discussed in Chapter IV, in practical cases of prestressing when the eccentricity e is equal or bigger than i, the value of the component X_{2N} is generally in the range of 29 to 1.4% of the value of the total reaction X_2, while the component X_{3N} is in the range of 75 to 0.4% of the value of the reaction X_3. This means that the percentage of error in the value of the reaction X due to the fact of neglecting the axial deformation caused by the unit force at the supports is of a small amount and can be neglected.

Substituting in the matrix equation (4) for the values of the different deformations after neglecting the mentioned terms we get:

$$\begin{vmatrix} (y^2 + 2/3y^3) & (1/3y^3 + y^2) & (-1/2y) \\ (1/3y^3 + y^2) & (2/3y^3 + 2y^2) & (-y) \\ (-1/2y) & (-y) & (2/3) \end{vmatrix} \begin{vmatrix} X_1 \\ X_2 \\ X_3 \end{vmatrix} = - \begin{vmatrix} 1 \\ 2 \\ 0 \end{vmatrix} P/(L/i)^2 \qquad (20)$$

where $y = h/L$ and $i^2 = I/A$

For each value of the ratio h/L there are corresponding values of parasitic reactions X_1, X_2 and X_3 in terms of $P/(L/i)^2$. These values are given in table (0.1)

The bending moment caused by the prestressing only is calculated from the following equation:

$$M = Mo + X_1M_1 + X_2M_2 + X_3M_3 \qquad (21)$$

therefore:

$$Mb = - x_1h - X_2h = -(X_1 + X_2)y\ L \qquad (21.a)$$

$$Mc_1 = -(X_1y + X_2Y - X_3)L \qquad (21.b)$$

$$Mc_2 = - X_1yL \qquad (21.c)$$

$$Mc_3 = (-X_2y + X_3)L \qquad (21.d)$$

$$Me = - X_2yL \qquad (21.e)$$

Table (0.2) gives the corresponding moment for each value of the ratio $y = h/L$ at different sections.

It is to be noted in this case that the value of Mo = 0 and the moment caused by prestressing is equal to the secondary moment.

Note 1

Comparing the two equations (18) and (18.a) giving the reaction before and after the terms in N_1 , N_2 , N_3 , N_1N_2, N_1N_3 and N_1N_3 being neglected we find

$$X_2 = - P\left[\frac{6y + 2/3\ (L/i)^2}{6y + (L/i)^2\ (6Y^3 + 2y^4 + 2/3) + (L/i)^4\ (1/6y^2 + 2/9y^3)}\right] \tag{18}$$

and $$X_2 = - P/(L/i)^2 \left[\frac{1}{1/4\ y^2 + 1/3y^3}\right] \tag{18.a}$$

In equation (18) we notice that the value of (6y) is very small compared to the term (L/i) and can be neglected and equation (18) becomes

$$X_2 = - P\left[\frac{2/3}{(6y^3 + 2y^4 + 2/3) + (L/i)^2\ (1/6y^2 + 2/9y^3)}\right]$$

but in the denominator the first term is very small compared to the second and can also be neglected, therefore

$$X_2 = - P\left[\frac{1}{(L/i)^2\ (1/4y^2 + 1/3y^3)}\right]$$

which is the same as equation (18.a). The same comparison can be done for X_3 between the two equations (19) and (19.a).

Note 2

If the frame has two non-equal spans L_1 and L_2 as in Fig. (2), the parasitic reactions and the secondary moments are calculated in the same manner as for the two equal spans, and equations (17), (18a), and (19a) become:

$$X_1 = \frac{-Pi^2}{3h}\left[\frac{(L_1^2 - L_2^2)}{1/3h^2L_1+1/3h^2L_2+1/6hL_1^2+1/6hL_2^2+5/6hL_1L_2+1/4L_1^2L_2+1/4L_1L_2^2}\right] \quad (22)$$

$$X_2 = \frac{-Pi^2}{h^2}\left[\frac{L_1^2L_2+L_1L_2^2+hL_1L_2+1/3hL_1^2+2/3hL_2^2}{1/3h^2L_1+1/3h^2L_2+1/6hL_1^2+1/6hL_2^2+5/6hL_1L_2+1/4L_1^2L_2+1/4L_1L_2^2}\right] \quad (23)$$

$$X_3 = \frac{-Pi^2}{hL_2}\left[\frac{3/2L_1^2L_2+3/2L_1L_2^2+hL_1L_2+hL_1^2+hL_2^2}{1/3h^2L_1+1/3h^2L_2+1/6hL_1^2+1/6hL_2^2+5/6hL_1L_2+1/4L_1^2L_2+1/4L_1L_2^2}\right] \quad (24)$$

To calculate the bending moment we use equation (21) with the previous values of X_1, X_2 and X_3.

Considering now the case when the cable profile is not coinciding with the centroidal axis but has an eccentricity e varying with the shape of the cable.

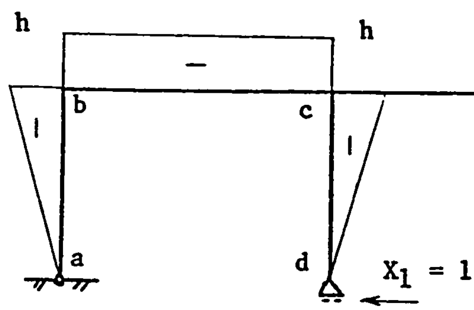
The following profiles are analysed:

1.b Linear Cable in the First Span with an Eccentricity e_1 at the Intermediate Column

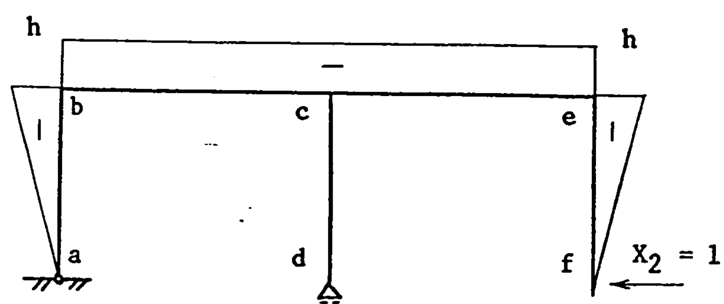
In this case the moment Mo due to the prestressing force and the eccentricity of the cable will be as shown in Fig. (7). This moment is not transmitted at the joint to the other members because it is an internal moment related only to the cable profile and the force P in the prestressed member.

By neglecting the terms in $\bar{N}_1^2$, $\bar{N}_2^2$, $\bar{N}_3^2$, $\bar{N}_1\bar{N}_2$, $\bar{N}_1\bar{N}_3$ and N_2N_3 in the deformation equations (8) to (16) we have

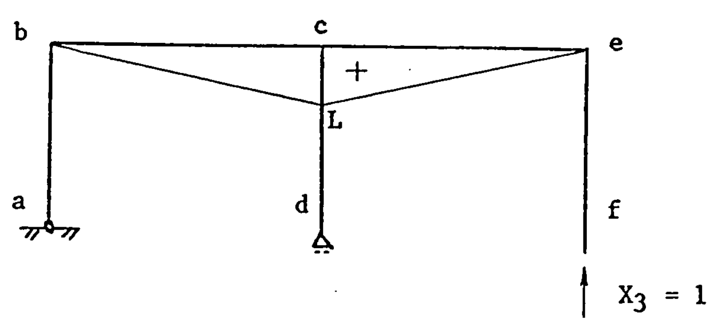
$$\delta_{10} = \int_0^L M_1 Mo\, dL/EI + \int_0^L N_1 No\, dL/AE = -(Pe_1Lh/EI) + PL/AE \quad (8.6)$$



M_1 - Diagram



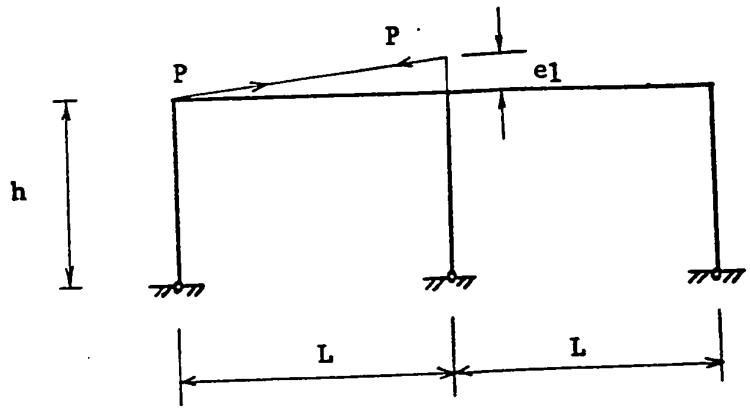
M_2 - Diagram



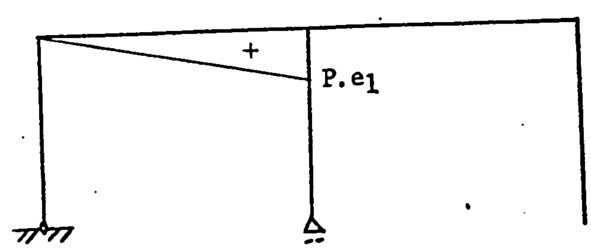
M_3 - Diagram

FIG. 6 Bending Moment Caused by the Unit

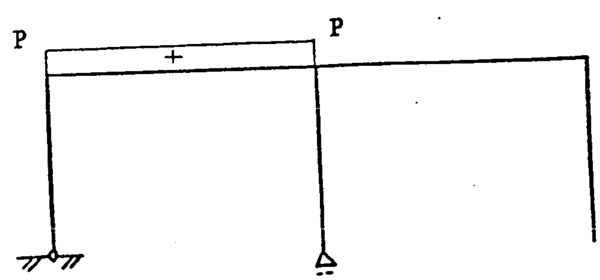
Force at the Supports



Cable Profile



Mo - Diagram



No - Diagram

FIG. 7 Linear Cable in the First Span with an Eccentricity e_1 at the Intermediate Column

$$= - (Pe_1 Lh/2EI) + (PL/AE) \tag{9.b}$$

$$\delta_{30} = \int_0^L M_3 M_o dL/EI + \int_0^L N_3 N_o dL/AE \tag{10.b}$$

$$= Pe_1 L^2/3EI + 0$$

$$\delta_{11} = \int_0^L M_1^2 dL/EI = (h^2 L + 2/3h^3)/EI \tag{11.b}$$

$$\delta_{12} = \int_0^L M_1 M_2 dL/EI = (h^2 L + 1/3h^3)/EI \tag{12.b}$$

$$\delta_{13} = \int_0^L M_1 M_3 dL/EI = - hL^2/2EI = \delta_{31} \tag{13.b}$$

$$\delta_{22} = \int_0^L M_2^2 dL/EI = (2h^2 L + 2/3h^3)/EI \tag{14.b}$$

$$\delta_{23} = \int_0^L M_2 M_3 dL/EI = - hL^2/EI = \delta_{32} \tag{15.b}$$

$$\delta_{33} = \int_0^L M_3^2 dL/EI = 2L^3/3EI \tag{16.b}$$

Substituting these values in equations (3a), (3b) and (3c) we get:

$$X_1 = - \frac{\begin{vmatrix} \int_0^L M_1 M_o dL/EI + \int_0^L N_1 N_o dL/AE & \int_0^L M_1 M_2 dL/EI & \int_0^L M_1 M_3 dL/EI \\ \int_0^L M_2 M_o dL/EI + \int_0^L N_2 N_o dL/AE & \int_0^L M_2^2 dL/EI & \int_0^L M_2 M_3 dL/EI \\ \int_0^L M_3 M_o dL/EI + \int_0^L N_3 N_o dL/AE & \int_0^L M_2 M_3 dL/EI & \int_0^L M_3^2 dL/EI \end{vmatrix}}{\begin{vmatrix} \int_0^L M_1^2 dL/EI & \int_0^L M_1 M_2 dL/EI & \int_0^L M_1 M_3 dL/EI \\ \int_0^L M_2 M_1 dL/EI & \int_0^L M_2^2 dL/EI & \int_0^L M_2 M_3 dL/EI \\ \int_0^L M_3 M_1 dL/EI & \int_0^L M_2 M_3 dL/EI & \int_0^L M_3^2 dL/EI \end{vmatrix}}$$

the same equation can be written:

$$X_1 = - \frac{\begin{vmatrix} \int_0^L M_1 M_o dL & \int_0^L M_1 M_2 dL & \int_0^L M_1 M_3 dL \\ \int_0^L M_2 M_o dL & \int_0^L M_2^2 dL & \int_0^L M_2 M_3 dL \\ \int_0^L M_3 M_o dL & \int_0^L M_2 M_3 dL & \int_0^L M_3^2 dL \end{vmatrix} 1/EI - \begin{vmatrix} \int_0^L N_1 N_o dL/A & \int_0^L M_1 M_2 dL/I & \int_0^L M_1 M_3 dL/I \\ \int_0^L N_2 N_o dL/A & \int_0^L M_2^2 dL/I & \int_0^L M_2 M_3 dL/I \\ \int_0^L N_3 N_o dL/A & \int_0^L M_2 M_3 dL/I & \int_0^L M_3^2 dL/I \end{vmatrix}}{A} \tag{25}$$

where A is the same denominator determinant in the previous equation.

We notice that the computed reaction is composed of two components: one due to the effect of the moment and the second due to the effect of the thrust. These components will be calculated separately then added as in the following equation

$$X = X_M + X_N$$

where X is the total parasitic reaction

X_M = the component of this reaction related to the moment

X_N = the component related to the thrust

and the secondary moment M caused by these reactions will have also two components M_M and M_N. Substituting for the value of the deformation in equations $(3)^a$, $(3)^b$, $(3)^c$ then solving these equations together we get

$$X_{1M} = + 1/2 \; Pe_1 L/h \left[\frac{2/3h + 1/2L}{2/3h^2 + 7/6\; hL + 1/2L^2}\right] \tag{26}$$

$$X_{2M} = - 1/2 \; Pe_1 L/h \left[\frac{1/3h + 1/4L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{27}$$

$$X_{3M} = - 1/2 \; P.e_1/L \tag{28}$$

Substituting in the matrix equation (4) for the values of the different deformations we get

$$\begin{bmatrix} (y^2 + 2/3y^3) & (1/3y^3 + y^2) & (-1/2y) \\ (1/3y^3 + y^2) & (2/3y^3 + 2y^2) & (-y) \\ (-1/2y) & (-y) & (2/3) \end{bmatrix} \begin{bmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{bmatrix} = - \begin{bmatrix} -1/2y \\ -1/2y \\ 1/3 \end{bmatrix} P.e/L$$

or $A \cdot X_M = B$ (29)

Matrix A is related to the deformations caused by the unit force acting at the supports and is the same for all the cable profiles.

Table (1.1) gives the values of the parasitic reaction components X_M for different ratios of $y = h/L$.

To calculate the values of the component X_N we proceed in the same manner as for X_M and we get

$$X_{1N} = - \frac{Pi^2}{h^2} \left[\frac{2/3hL + 1/2L^2}{2/3h^2 + 7/6hL + 1/2L^2} \right] \quad (30)$$

$$X_{2N} = - \frac{Pi^2}{h^2} \left[\frac{2/3hL + 3/4L^2}{2/3h^2 + 7/6hL + 1/2L^2} \right] \quad (31)$$

$$X_{3N} = - \frac{Pi}{Lh} \left[\frac{3/2hL + 3/2L^2}{2/3h^2 + 7/6hL + 1/2L^2} \right] \quad (32)$$

The equations for X_N could also be written in the form of the matrix equation

$$|A| \begin{vmatrix} X_{1N} \\ X_{2N} \\ X_{3N} \end{vmatrix} = - \begin{vmatrix} 1 \\ 1 \\ 0 \end{vmatrix} P/(L_{ii})^2 \quad (33)$$

where $|A|$ is the same matrix as in equation (29).

Table (1.2) shows the values of the reaction components X_N for different ratios $y = h/L$.

The final value of the parasitic reaction caused by prestressing is $X = X_M + X_N$ or table (1.1) + table (1.2).

Substituting in equation (21) for the moment caused by prestressing only in the frame we have

$$Mb = -(X_1 + X_2)yL = -(X_{1M} + X_{2M})yL - (X_{1N} + X_{2N})yL \tag{21.a.1}$$

$$Mc_1 = Mo - (X_1y + X_2y - X_3)L \tag{21.b.1}$$

$$= Mo - (X_{1M}y + X_{2M}y - X_{3M})L - (X_{1N}y + X_{2N}y - X_{3N})L$$

$$Mc_2 = - X_1yL = - X_{1M}yL - X_{1N}yL \tag{21.c.1}$$

$$Mc_3 = (-X_2y + X_3)L = (-X_{2M}y + X_{3M})L + (-X_{2N}y + X_{3N})L \tag{21.d.1}$$

$$Mc = - X_2yL = - X_{2M}yL - X_{2N}yL \tag{21.e.1}$$

Table (1.3) shows the moment $Mo + M_M$ at different sections for corresponding values of $y = h/L$ and table (1.4) shows the values of M_N.

The final moment due to prestressing only in the frame is

$$M = (Mo + M_M) + M_N$$

$$= \text{table } (1.3) + \text{table } (1.4)$$

Substituting in equations (26) and (30) for $y = h/L$ we get

$$X_{1M} = - Pe_1/yL \left[\frac{1/3y + 1/4}{2/3y^2 + 7/6y + 1/2} \right] \tag{34}$$

$$X_{1N} = - P/y^2(L/i)^2 \left[\frac{2/3y + 1/2}{2/3y^2 + 7/6y + 1/2} \right] \quad (35)$$

therefore

$$\frac{X_{1N}}{X_{1M}} = i^2/yLe_1 \left[\frac{2/3y + 1/2}{1/3y + 1/4} \right] \quad (36)$$

Assuming that d varies between L/10 and L/40, therefore i = d/6 will vary between L/60 and L/240. The eccentricity e_1 may vary in practice between 0 and 0.45d, assuming that 0.05d is the minimum cover over the cable. For i = L/60 and e_1 = a very small value $\therefore$ i

$$\frac{X_{1N}}{X_{1M}} = 1/60(i/e_1) \left[\frac{2/9y + 1/6}{1/3y + 1/4} \right] = 1/60y(i/e_1)\,\Phi y$$

The form Φy is not a governing factor since its value can be considered constant for different value of y.

$\Phi y = 0.66664$ for $y = 0$

$= 0.66552$ for $y = 1$

$= 0.66636$ for $y = 0.1$

$= 0.66648$ for $y = 10$

and the ratio $\frac{X_{1N}}{X_{1M}}$ is depending on (i/e_1) and (L/y) when (e_1) is very small or close to zero, the value of X_{1N} is very big. If $i/e_1 = 100$, (consider y = 0.66 for all values of y)

$$\frac{X_{1N}}{X_{1M}} = 1.05/y$$

The smaller is the value of y the bigger is the value of X_{1N} compared to X_{1M} when $i/e_1 = 10$

$$\frac{X_{1N}}{X_{1M}} = 0.105/y$$

If y is less than 1, X_{1N} is less than 10.5% of X_{1M} when $i/e_1 = 1$

$$\frac{X_{1N}}{X_{1M}} = 0.0105/y$$

If y is less than 1, X_{1N} is less than 1.05% of X_{1M} and can be neglected.

Similarly from equations (27) and (31):

$$\frac{X_{2N}}{X_{2M}} = i^2/yLe1\left[\frac{2/9y + 1/4}{1/6y + 1/8}\right] = (i/L)\ (i/e1)\ (1/y)\ (\phi y) \qquad (37)$$

the value of $\phi y = 1.921$ for $y = 0.1$

$= 1.622$ for $y = 1$

$= 1.380$ for $y = 10$

the variation of ϕy with respect to y is small and we can use the same previous analysis for X_1 in the case of X_2.

Consider now the third reaction:

$$\frac{X_{3N}}{X_{3M}} = i^2/Le_1\left[\frac{y + 1}{y}\right] = (i/L)\ (i/e_1)\ (\phi y) \qquad (38)$$

$\phi y = 11$ for $y = 0.1$

$= 2$ for $y = 1$

$= 1.1$ for $y = 10$

Conclusion:

For the three parasitic reactions X_1, X_2 and X_3, the ratio between the component related to thrust to the one related to moment:

- increase with the decrease of the ratio L/i
- increase with the increase of the ratio i/e

- increase with the decrease of the ratio $y = h/L$

Note:

If the frame has two non-equal spans L_1 and L_2 as in Fig. (2), the parasitic reactions and the secondary moment are calculated in the same manner as for two equal spans, and equations (26), (27), (28), (30), (31) and (32) become:

$$X_{1M} = + \frac{Pe_1L_1}{2h} \beta \left(2/3hL_2 + 1/4L_1L_2 + 1/4L_2^2\right) \tag{39}$$

$$X_{2M} = - \frac{Pe_1L_1}{2h} \beta \left(1/4L_1L_2 + 1/3hL_2\right) \tag{40}$$

$$X_{3M} = - \frac{Pe_1L_1}{2L_2} \beta \left(2/3h^2 + 1/3hL_1 + 5/6hL_2 + 1/2L_1L_2\right) \tag{41}$$

and

$$X_{1N} = - \frac{PL_1(i)^2}{h^2} \beta \left(1/3hL_1 + 1/3hL_2 + 1/4L_1L_2 + 1/4L_1^2\right) \tag{42}$$

$$X_{2N} = - \frac{PL_1(i)^2}{h^2} \beta \left(1/3hL_1 + 1/3hL_2 + 3/4L_1L_2\right) \tag{43}$$

$$X_{3N} = - \frac{PL_1(i)^2}{hL_2} \beta \left(hL_1 + 1/2hL_2 + 3/2L_1L_2\right) \tag{44}$$

where $$\beta = \frac{1}{1/3h^2L_1 + 1/3h^2L_2 + 1/6hL_1^2 + 1/6hL_2^2 + 5/6hL_1L_2 + 1/4L_1^2L_2 + 1/4L_1L_2^2} \tag{45}$$

The total value of the parasitic reaction is

$$X = X_{N1} + X_M$$

The bending moment is calculated from equation (21) using the above values of X_1, X_2 and X_3.

2.a Linear Cable of Triangular Shape in the First Span with an Eccentricity e_2 at the Edge Column

In this case the moment Mo will be as shown in Fig. (8) and the deformations caused by this moment are

$$\delta_{10} = - Pe_2Lh/2EI + PL/AE \tag{46}$$

$$\delta_{20} = - Pe_2Lh/2EI + PL/AE \tag{47}$$

$$\delta_{30} = + 1/6 \; Pe_2L^2 \tag{48}$$

The value of the other deformations caused by the unit reactions are the same for all the cases. Substituting in equations (3a), (3b), (3c) and solving them we get

$$X_{1M} = \frac{Pe_2L}{2h}\left[\frac{2/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{49}$$

$$X_{2M} = \frac{Pe_2L}{2h}\left[\frac{1/6h + 1/4L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{50}$$

$$X_{3M} = \frac{Pe_2}{2L}\left[\frac{1/6hL - 1/3h^2 + 1/2L^2}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{51}$$

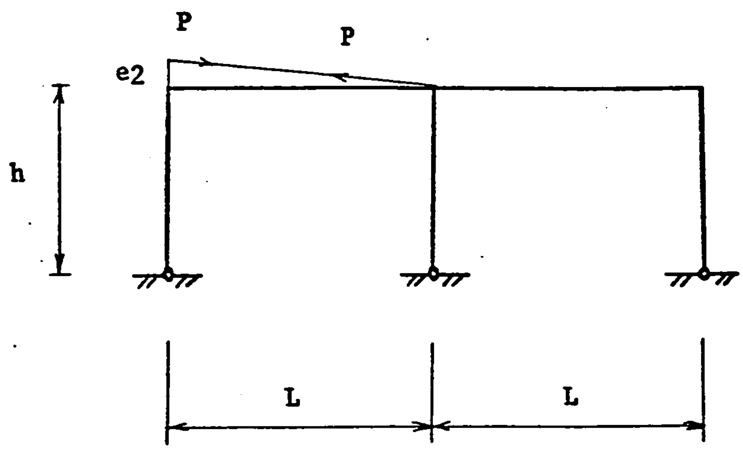
and the values of the components X_{1N}, X_{2N} and X_{3N} are the same as in equations (30), (31) and (32).

The matrix form of the components X_M and X_N is:

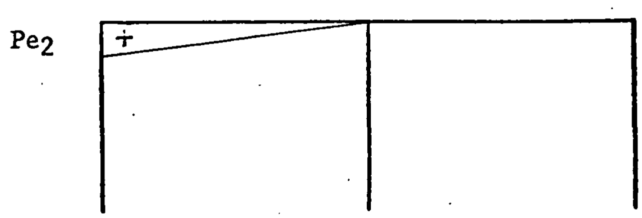
$$\lfloor A \rfloor \begin{bmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{bmatrix} = - \begin{bmatrix} -1/2y \\ -1/2y \\ +1/6 \end{bmatrix} Pe_2/L \tag{52}$$

and

$$[A] \begin{bmatrix} X_{1N} \\ X_{2N} \\ X_{3N} \end{bmatrix} = - \begin{bmatrix} -1 \\ -1 \\ 0 \end{bmatrix} P/(L/i)^2 \tag{53}$$



Cable Profile



Mo - Diagram

FIG. 8 Linear Cable in the First Span with an Eccentricity e_2 at the Edge Column where A is the same matrix as in equation (29).

Tables (2.1) and (1.2) give the values of X_M and X_N respectively for different ratios $y = h/L$.

The final value of the parasitic reaction $X = X_N + X_M$

= table (2.1) + table (1.2)

The bending moment is given by equation (21); table (2.2) and (1.4) give the values of $(Mo + M_M)$ and M respectively and the final moment =

$$M = (Mo + M_M) + M_N$$

= table (2.2) + table (1.4)

If the frame has two non-equal spans L_1 and L_2, equations (49), (50) and (51) become:

$$X_{1M} = \frac{Pe_2L_1}{2h} \beta \; (1/6hL_1 + 1/2hL_2 + 1/4L_1L_2 + 1/4L_2^2) \qquad (54)$$

$$X_{2M} = \frac{Pe_2L_1}{2h} \beta \; (1/6hL_1 + 1/4L_1L_2) \qquad (55)$$

$$X_{3M} = \frac{Pe_2L_1}{2L_2} \beta \; (1/3hL_1 - 1/6hL_2 - 1/3h^2 + 1/2L_1L_2) \qquad (56)$$

where β is a factor given in equation (45).

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equation (42), (43) and (44).

The bending moment is calculated from equation (21) using the values of X_1, X_2 and X_3 computed above.

2.b Linear Cable of Triangular Shape in the First Span with an Eccentricity e_λ at a Distance λL from the Edge Column (Fig. 9)

The deformations at the supports caused by the applied moment Mo are:

$$\delta_{10} = P.e_\lambda Lh/2EI + PL/AE \tag{57}$$

$$\delta_{20} = P.e_\lambda Lh/2EI + PL/AE \tag{58}$$

$$\delta_{30} = -Pe_\lambda L^2(1+\lambda)/\ EI \tag{59}$$

The equations giving the parasitic reactions are:

$$X_{1M} = -\frac{Pe_\lambda L}{2h}\left[\frac{2/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{60}$$

$$X_{2M} = \frac{Pe_\lambda L}{2h}\left[\frac{h(1/2\lambda - 1/6) + L(1/2\lambda - 1/4)}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{61}$$

$$X_{3M} = \frac{Pe_\lambda}{2L}\left[\frac{1/3h^2\ (\lambda + 1) + L^2(\lambda - 1/2) + hL(4\lambda/3 - 1/6)}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{62}$$

The matrix form of the component X_M is

$$|A| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} 1/2y \\ 1/2y \\ -1/6(1+\lambda) \end{vmatrix} \cdot P.e/L \tag{63}$$

and the one of X_N is given by equation (53). Tables (23) and (12) give the values of X_M and X_N respectively for different ratios h/L.

The bending moment is calculated from equation 21 and tables (24) and (14) give the values of $(Mo + M_M)$ and M_N respectively.

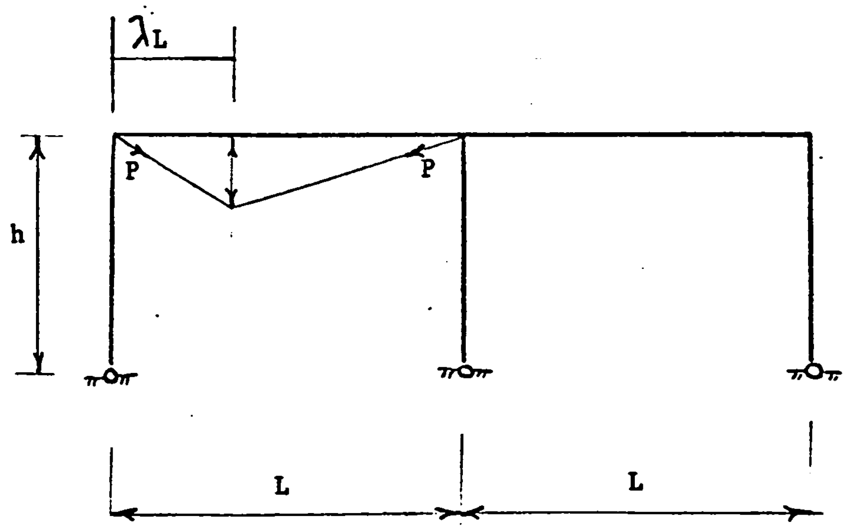
If the frame has two non-equal spans L_1 and L_2, equations (60), (61) and (62) become

$$X_{1M} = -\frac{PeL_1}{2h}\beta\left\{1/6hL_1+1/2hL_2+1/4L_1L_2+1/4L_2^2+1/6\lambda h(L_2-L_1)\right\} \tag{64}$$

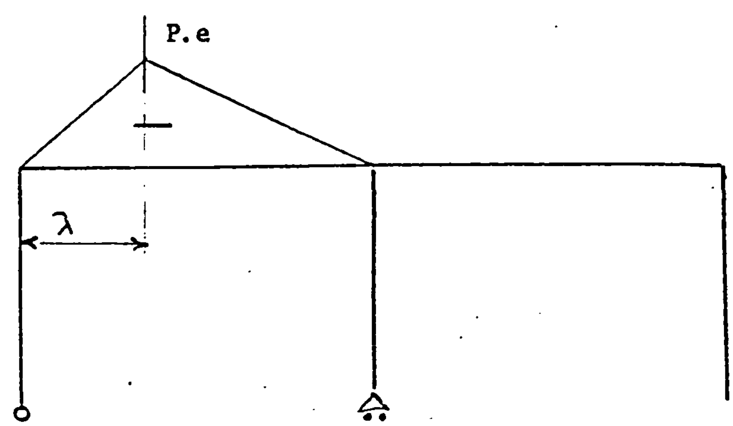
$$X_{2M} = -\frac{PeL_1}{2h}\beta\left\{1/4L_1L_2+1/6hL_1-1/3\lambda h(1/2L_1+L_2)-1/2\ L_1L_2\right\} \tag{65}$$

$$X_{3M} = \frac{PeL_1}{2L_2}\beta\left\{1/3hL_1(2\lambda-1)+hL_2(2/3\lambda+1/6)+1/3h^2(\lambda+1)+L_1L_2(\lambda-1/2)\right\} \tag{66}$$

and the values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (42), (43) and (44).



Cable Profile



Mo - Diagram

FIG. 9 Cable Profile of Triangular Shape in the First Span with an Eccentricity e at a Distance L from the Edge Column

3. Parabolic Cable in the First Span with an Eccentricity e_3 at the Middle

The bending moment Mo is shown in Fig. (10) and the deformations caused by this moment are

$$\delta_{10} = \frac{2Pe_3Lh}{3EI} + PL/AE \tag{67}$$

$$\delta_{20} = \frac{2Pe_3Lh}{3EI} + PL/AE \tag{68}$$

$$\delta_{30} = -\frac{Pe_3L^2}{3EI} + 0 \tag{69}$$

and the parasitic reactions X_1, X_2 and X_3 are calculated from equations $(3)^a$, $(3)^b$ and $(3)^c$

$$X_{1M} = -\frac{2Pe_3L}{3h}\left[\frac{2/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{70}$$

$$X_{2M} = \frac{2Pe_3L}{3h}\left[\frac{1/12h}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{71}$$

$$X_{3M} = \frac{2Pe_3h}{3L}\left[\frac{1/2h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \tag{72}$$

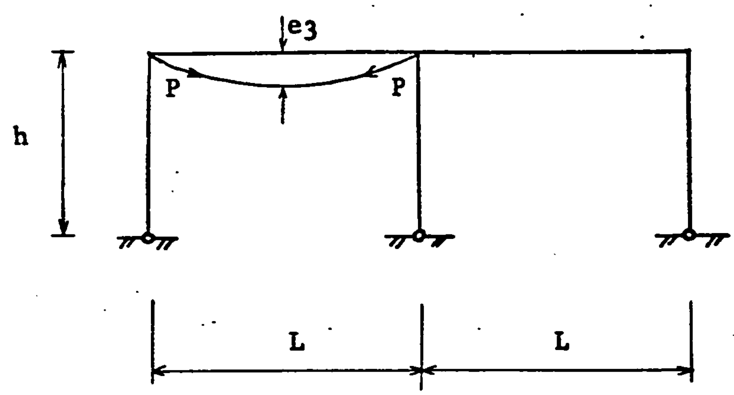
and the values of X_{1N}, X_{2N} and X_{3N} are given in equations (30), (31) and (32)

The matrix form of the components X_M is:

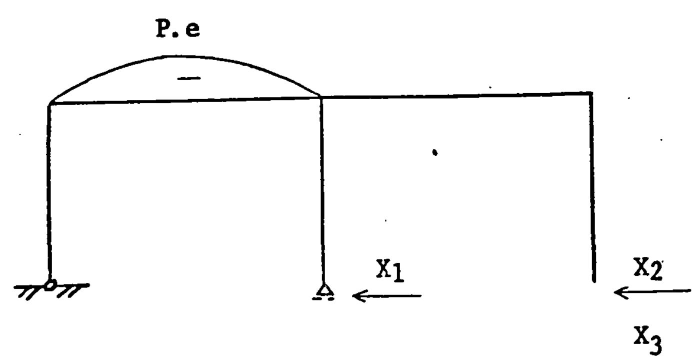
$$|A| \cdot \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} +2/3y \\ +2/3y \\ -1/3 \end{vmatrix} P.e_3/L \tag{73}$$

and the one of X_N is given by equation (53).

Tables (3.1) and (1.2) give the values of X_M and X_N respectively for different ratios $y = h/L$.



Cable Profile



Mo. Diagram

FIG.10 Parabolic Cable in the First Span with an Eccentricity e_3 at the Middle

The bending moment is given by equation (21) and tables (3.2) and (1.4) give the values of $(Mo + M_M)$ and M_N respectively.

<u>Note</u>:

If the frame has two non-equal spans L_1 and L_2, equations (70), (71) and (72) become

$$X_{1M} = -\frac{2Pe_3L_1}{3h}\beta\left\{1/12hL_1 + 7/12hL_2 + 1/4L_1L_2 + 1/4L_2^2\right\} \quad (74)$$

$$X_{2M} = -\frac{2Pe_3L_1}{3h}\beta\left\{1/12hL_1 - 1/6hL_2\right\} \quad (75)$$

$$X_{3M} = \frac{2Pe_3L_1}{3L_2}\beta\left\{1/2h^2 + 1/2hL_2\right\} \quad (76)$$

where β is a factor given in equation (45)

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (42), (43) and (44).

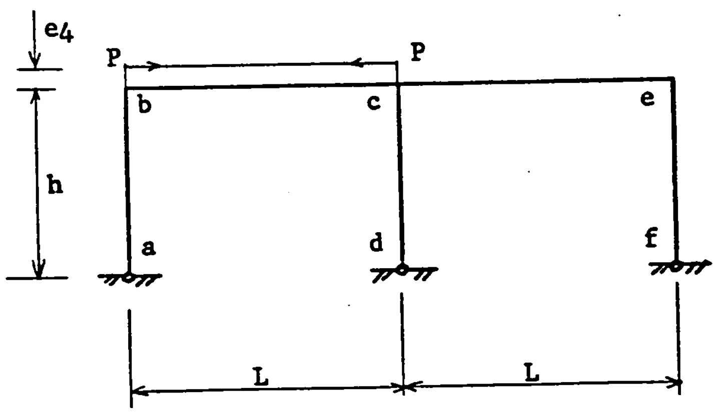
4. <u>Linear Cable in the First Span Parallel to the Centroidal Axis</u>

In this case the cable profile is equivalent to the superposition of the two cable profiles shown in Fig. (11). Hence X_{1M} = the sum of equations (26) and (49) with an eccentricity e_4

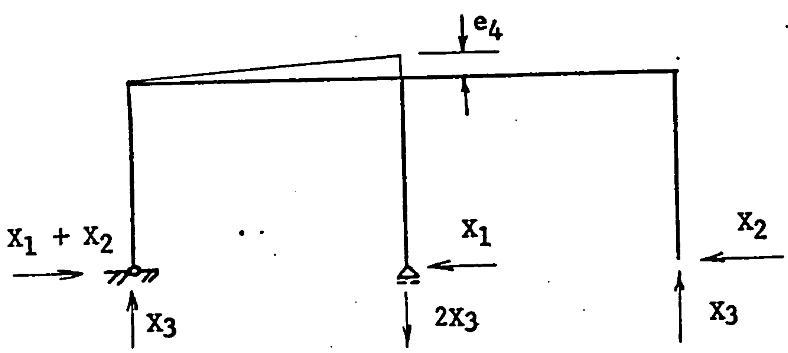
$$X_{1M} = \frac{Pe_4L}{2h}\left[\frac{4/3h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right] \quad (77)$$

$$X_{2M} = -\frac{Pe_4L}{2h}\left[\frac{1/6h}{2/3h^2 + 7/6hl + 1/2L^2}\right] \quad (78)$$

$$X_{3M} = -\frac{Pe_4}{2L}\left[\frac{h^2 + hL}{2/3h^2 + 7/6hL + 1/2L^2}\right] \quad (79)$$



Cable Profile



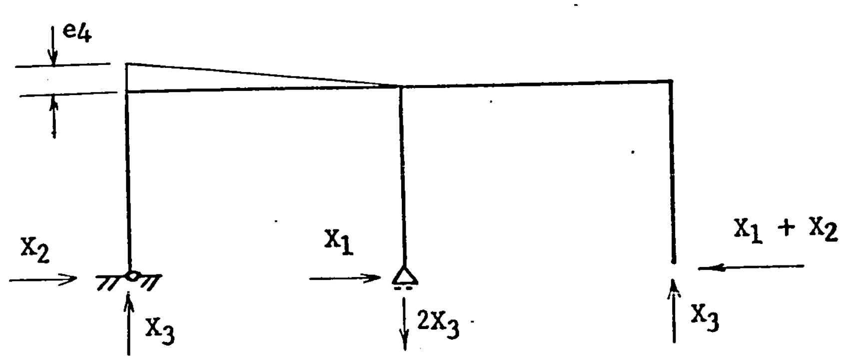


FIG. 11 Cable Profile in the First Span

Parallel to the Centroidial Axis

The values of X_{1N}, X_{2N} and X_{3N} a·· the same as in equations (30), (31) and (32).

The matrix form of the components X_M is:

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -y \\ -y \\ 1/2 \end{vmatrix} \cdot P.e_4/L \tag{80}$$

and the one for X_N is given in equation (53).

Tables (4.1) and (1.2) give the values of X_M and X_N respectively for different ratios $y = h/L$.

The bending moment is calculated from equation (21) and tables (4.2) and (1.4) give the values of $(Mo + M_M)$ and $(M\ )$ respectively.

If the frame has two non-equal spans L_1 and L_2 equations (77), (78) and (79) become

$$X_{1M} = \frac{Pe_4L_1}{2h} \beta \left\{ 1/6hL_1 + 7/6hL_2 + 1/2L_1L_2 + 1/2L_2^2 \right\} \tag{81}$$

$$X_{2M} = \frac{Pe_4L_1}{2h} \beta \left\{ 1/6hL_1 - 1/3hL_2 \right\} \tag{82}$$

$$X_{3M} = \frac{-Pe_4L_1}{2L_2} \beta \left\{ h^2 + hL_2 \right\} \tag{83}$$

where β is a factor given in equation (45).

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (42), (43) and (44).

5. Linear Cable in the Whole Girder with an Eccentricity e_5 at the Intermediate Column

The frame is symmetrical as shown and the cable profile is equivalent to the superposition of the two profiles shown in Fig. (12).

The values of the parasitic reactions are:

$$X_{1M} = 0 \tag{84}$$

$$X_{2M} = 0 \tag{85}$$

X_{3M} = twice the value calculated in equation (28) with an eccentricity e_5

$$= - P.e_5/L \tag{86}$$

The values of the components X_{1N}, X_{2N} and X_{3N} are given in the equations (17), (18.a) and (19.a) respectively. The final value of $X = X_N + X_M$.

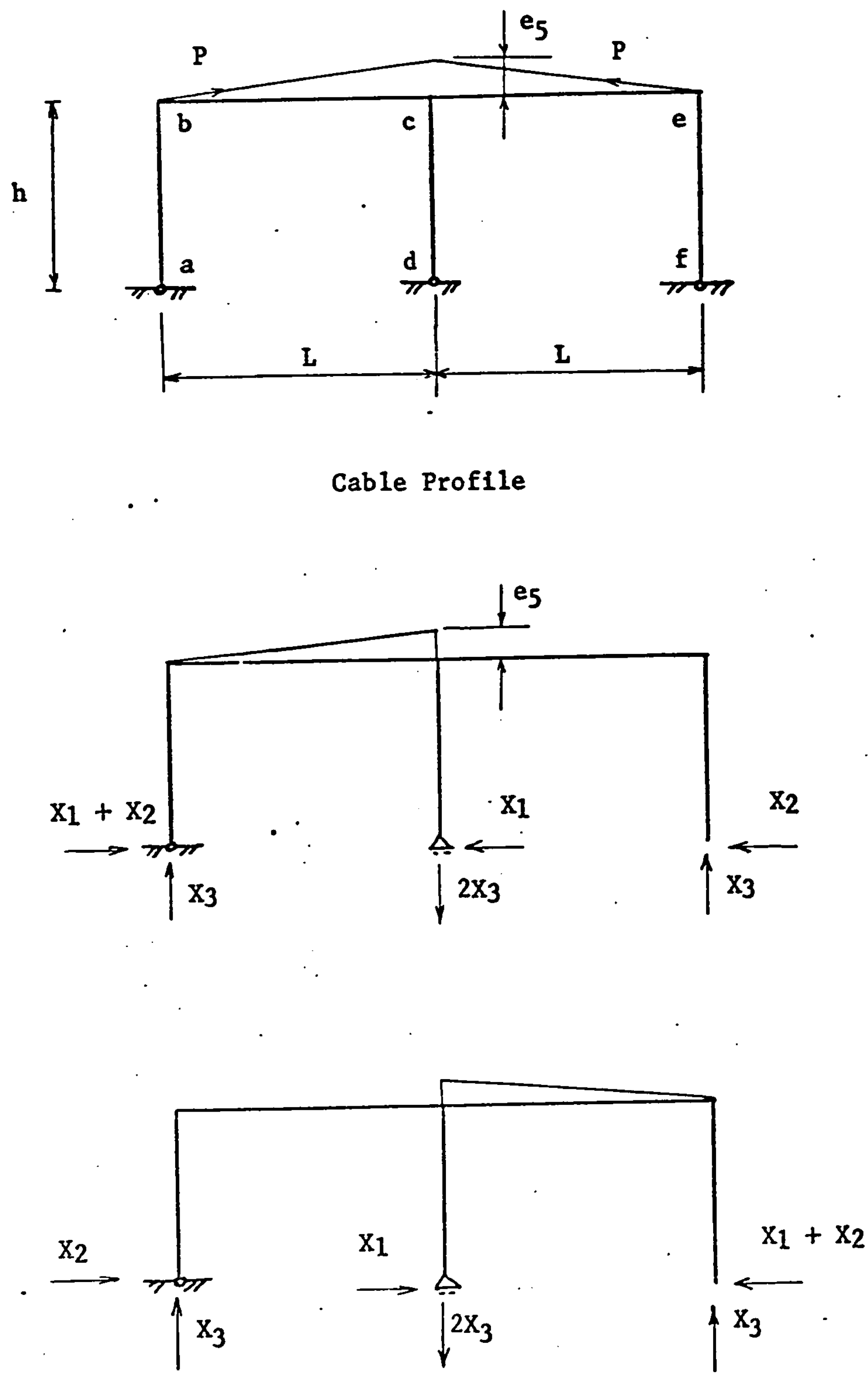
Tables (5.1) and (0.1) give the values of X_M and X_N respectively for different ratios $y = h/L$.

The matrix form for the components X_M is:

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -1/2y \\ -y \\ +2/3 \end{vmatrix} Pe_5/L \tag{87}$$

and the one for X_N is given in equation (20).

The bending moment at any section is calculated from equation (21):



Cable Profile

FIG. 12 Linear Cable in the Whole Girder with an Eccentricity e_5 at the Intermediate Column

$M = (Mo + M_M) + M_N$

The value of $(Mo + M_M)$ is found to be zero for all the values of the ratio $y = h/L$. The value of M_N is given in table (0.2) and the final moment $M = M_N$. This means that the last cable profile shown in Fig. (12) produces the same bending moment as the first cable profile shown in Fig. (5); and the eccentricity e_5 has no effect on the prestressing.

If the frame has two non-equal spans L_1 and L_2:

$$X_{1M} = \text{zero} \tag{88}$$

$$X_{2M} = \text{zero} \tag{89}$$

$$X_{3M} = -\frac{Pe_5}{L_2}\,\beta\left\{ 1/6hL_1^2 + 1/2hL_2^2 + 1/2hL_1L_2 + 1/4L_1^2L_2 + 1/4L_1L_2^2 + 1/3h^2L_1 + 1/3h^2L_2 \right. \tag{90}$$

where β is a factor given in equation (45).

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (22), (23) and (24).

6. Linear Cable in the Whole Girder with an Eccentricity e_6 at the Two Edge Columns

The frame is symmetrical and the cable profile is equivalent to the superposition of the two profiles shown in Fig. (13).

The values of the parasitic reactions are:

$$X_{1M} = 0 \tag{91}$$

$$X_{2M} = X_{1M}' + 2X_{2M}'$$

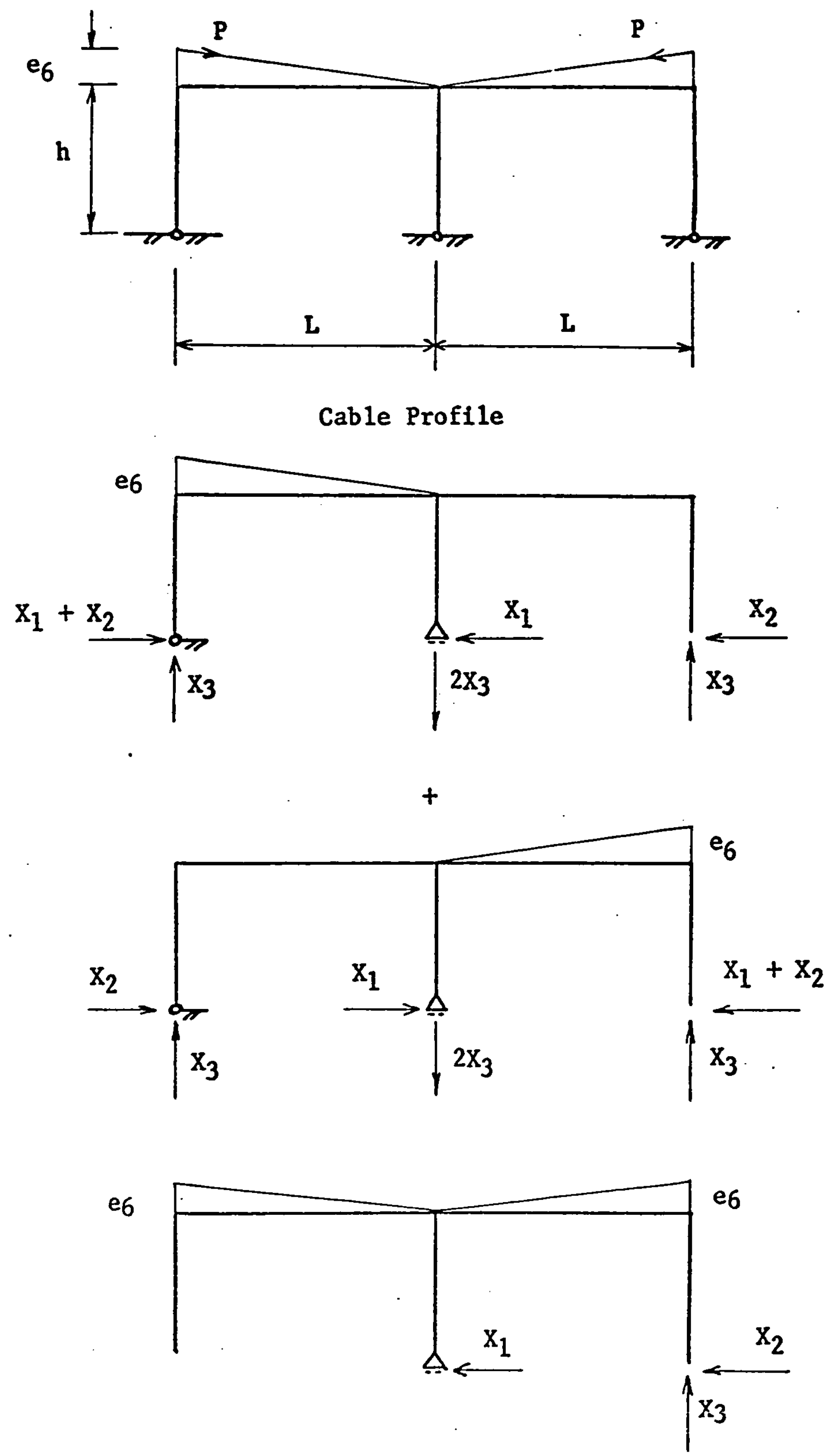


FIG. 13 Linear Cable in the Girder with an Eccentricity e_6 at the Two Edge Columns

= equation (49) + twice equation (50) with an eccentricity e_6

$$= \frac{Pe_6L}{2h} \left[\frac{(h + L)}{2/3h^2 + 7/6hL + 1/2L^2} \right] \tag{92}$$

$X_{3M} = 2X'_{3M}$ = twice equation (51)

$$= \frac{P.e_6}{L} \left[\frac{1/6hL - 1/3h^2 + 1/2L^2}{2/3h^2 + 7/6hL + 1/2L^2} \right] \tag{93}$$

The values of the components X_{1N}, X_{2N} and X_{3N} are given in equations (17), (18.a) and (19.a) respectively.

The final value of $X = X_N + X_M$.

Tables (6.1) and (0.1) give the values of X_M and X_N respectively for different ratios $y = h/L$.

The matrix form of the components X_M is:

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -1/2y \\ -y \\ 1/3 \end{vmatrix} P.e_6/L \tag{94}$$

and the one for the component X_N is given in equation (20).

The bending moment is calculated from equation (21) and Tables (6.2) and (0.2) give the values of $(Mo + M_M)$ and M_N respectively. If the frame is composed of two non-equal spans :

$$X_{1M} = 1/2Pe_6\, \beta \left\{ (L_1^2 - L_2^2)\cdot 1/6 \right\} \tag{95}$$

$$X_{2M} = \frac{Pe_6}{2h}\, \beta \left\{ 1/6hL_1^2 + 1/3hL_2^2 + 1/2hL_1L_2 + 1/2L_1^2L_2 + 1/2L_1L_2^2 \right\} \tag{96}$$

$$X_{3M} = - \frac{Pe_6}{2L_2} \beta \left\{ 1/3h^2 L_1 + 1/3h^2 L_2 - 1/3hL_1^2 - 1/2 L_1^2 L_2 - 1/2L_1L_2^2 \right\} \quad (97)$$

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (22), (23) and (24).

7. Parabolic Cable in Both Spans with an Eccentricity e_7 at the Middle of Each One

The frame is symmetrical and the cable profile is equivalent to the superposition of the two profiles shown in Fig. (14).

The values of the parasitic reactions are:

$$X_{1M} = 0 \quad (98)$$

$$X_{2M} = - \frac{2Pe_7L}{3h} \left\{ \frac{1/2h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \quad (99)$$

$$X_{3M} = \frac{2Pe_7h}{3L} \left\{ \frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \quad (100)$$

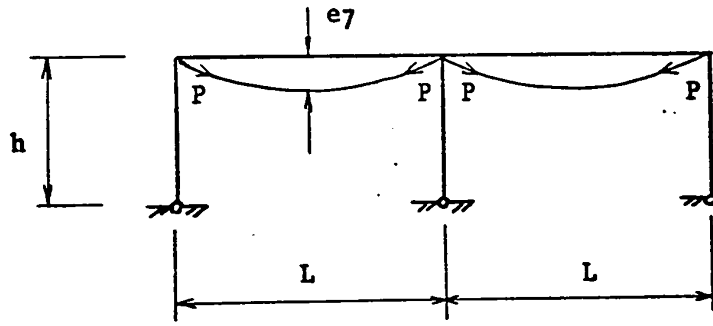
The values of the components X_{1N},X_{2N} and X_{3N} are given respectively in equations (17), (18.a) and (19.a).

Tables (7.1) and (0.1) give the values of X_M and X_N respectively for different ratios h/L.

The matrix form of the component X_M is:

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -2/3y \\ -4/3y \\ +2/3 \end{vmatrix} Pe_7/L \quad (101)$$

and the one for X_N is given in equation (20).



Cable Profile

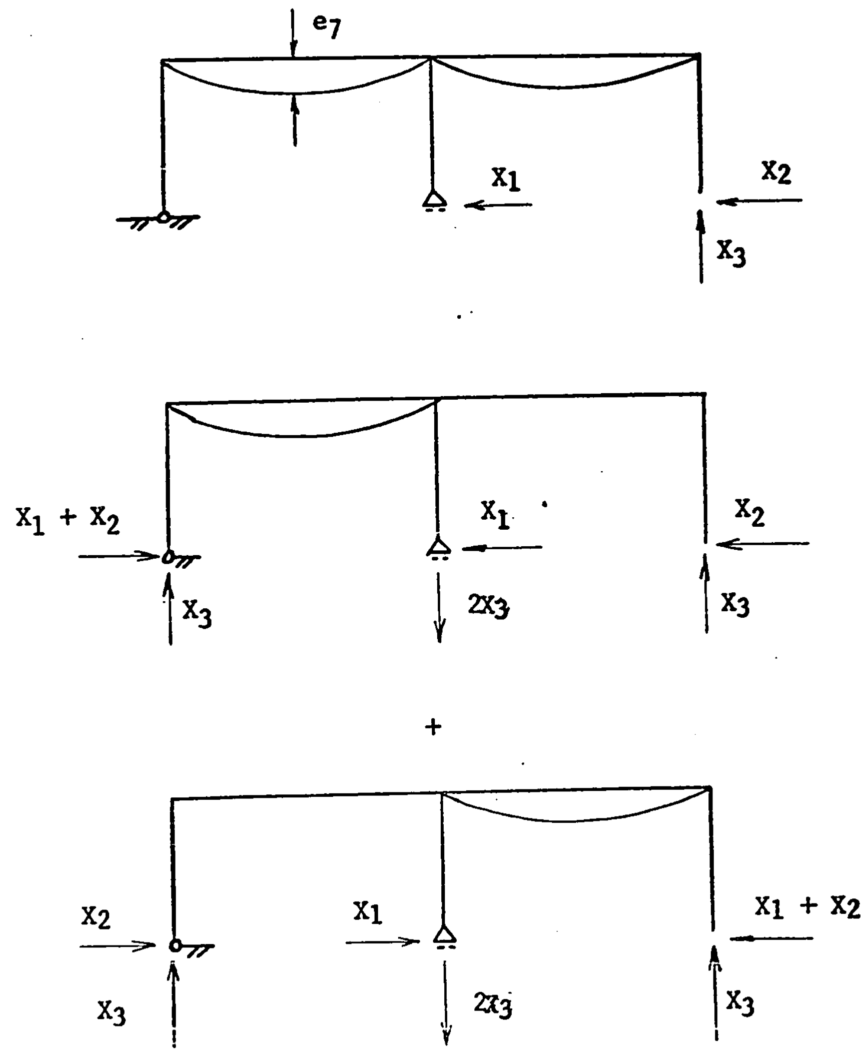


FIG.14 Continuous Parabolic Cable in Both Spans

with an Eccentricity e_7 at the Middle

The bending moment is calculated from equation (21) and Tables (7.2) and (0.2) give the values of $(Mo + M_M)$ and M_N respectively.

If the frame has two non-equal spans L_1 and L_2, equations (98), (99) and (100) become

$$X_{1M} = - 2/3Pe_7 \beta \frac{(L_1^2 - L_2^2)}{12} \qquad (102)$$

$$X_{2M} = - \frac{2Pe_7}{3h} \beta (1/12hL_1^2 + 1/6hL_2^2 + 1/4hL_1L_2 + 1/4L_1^2L_2 + 1/4L_1L_2^2) \qquad (103)$$

$$X_{3M} = 2Pe\ L\ \beta (1/2hL_1 + 1/2hL_2 + L_1L_2) \qquad (104)$$

when β is a factor given in equation (45)

The values of the components X_{1N}, X_{2N} and X_{3N} are the same as in equations (22), (23) and (24) respectively.

8. Linear Cable in the Whole Girder Parallel to the Centroidal Axis with an Eccentricity e_8

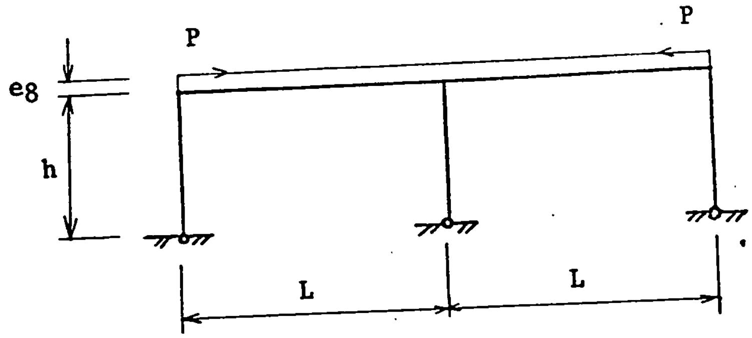
The frame is symmetrical and the cable profile is equivalent to the superposition of the two cable profiles shown in firgure (15).

The values of the parasitic reactions e_8 are:

$$X_{1M} = 0 \qquad (105)$$

$$X_{2M} = \frac{Pe_8L}{2h} \left\{ \frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \qquad (106)$$

$$X_{3M} = \frac{Pe_8}{L} \left\{ \frac{h^2 + hL}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \qquad (107)$$



Cable Profile

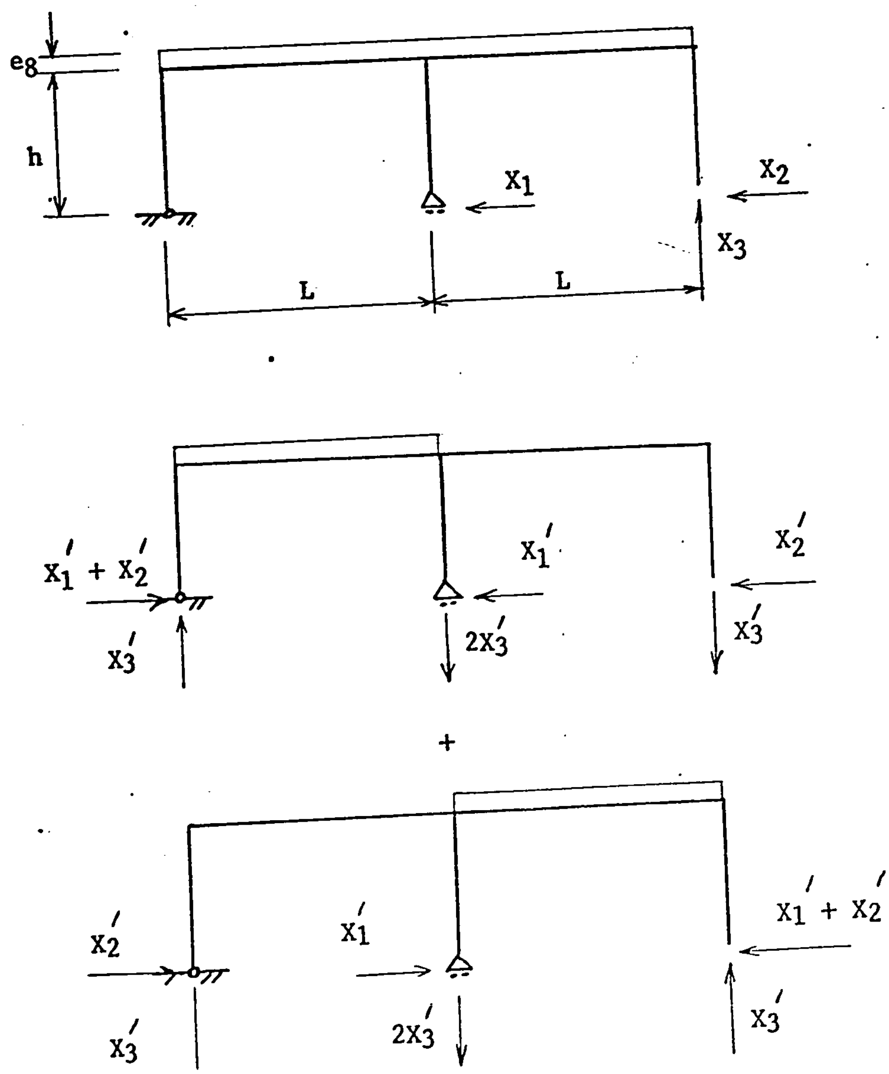


FIG. 15 Cable in the Girder Parallel to the Centroidal Axis with an Eccentricity e_8

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equation (17), (18.a) and (19.a).

Tables (8.1) and (0.1) give the values of X_M and X_N respectively.

The matrix form for the components X_M is:

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -y \\ -2y \\ 1 \end{vmatrix} Pe_8/L \qquad (108)$$

and the one for X_N is given in equation (20).

The bending moment is calculated from equation (21) and table (8.2) and (0.2) give the values of $(Mo + M_M)$ and M_N respectively.

If the frame is composed of two non-equal spans L_1 and L_2, equations (105),(106) and (107) become

$$X_{1M} = \frac{Pe_8}{2h} \left\{ \frac{(L_1^2 - L_2^2)}{6} \right\} \beta \qquad (109)$$

$$X_{2M} = \frac{Pe_8}{2h} \beta (1/6hL_1^2 + 1/3hL_2^2 + 1/2hL_1L_2 + 1/2L_1^2L_2 + 1/2L_1L_2^2) \qquad (110)$$

$$X_{3M} = - \frac{Pe_8}{L_2} \beta (1/2h^2L_1 + 1/2h^2L_2 + hL_1L_2) \qquad (111)$$

when β is a factor given in equation (45)

The values of the components X_{1N}, X_{2N} and X_{3N} are the same as in equations (22), (23) and (24) respectively.

9. Parabolic Cable in the Whole Girder with an Eccentricity e_9 at the Middle

In the case the moment Mo will be as shown in Fig. (16) and the deformations caused by the prestressing are

$$\delta_{10} = 2/3Pe_9Lh/EI + PL/AE \tag{112}$$

$$\delta_{20} = 4/3Pe_9Lh/EI + 2PL/AE \tag{113}$$

$$\delta_{30} = 5/6Pe_9L^2/EI \tag{114}$$

By substituting for these values in equations $(3)^a$, $(3)^b$ and $(3)^c$ and solving them we get

$$X_{1M} = 0 \tag{115}$$

$$X_{2M} = -\frac{Pe_9L}{12h}\left\{\frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{116}$$

$$X_{3M} = \frac{Pe_9}{6L}\left\{\frac{5h^2 + 8hL + 3L^2}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{117}$$

The values of the components X_{1N}, X_{2N} and X_{3N} are the same as in equations (17), (18.a) and (19.a).

The matrix form for the components X_M is:

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} 2/3y \\ 4/3y \\ -5/6 \end{vmatrix} Pe_9/L \tag{118}$$

and the one for X_N is given in equation (20). Tables (9.1) and (0.1) give the values of X_M and X_N respectively.

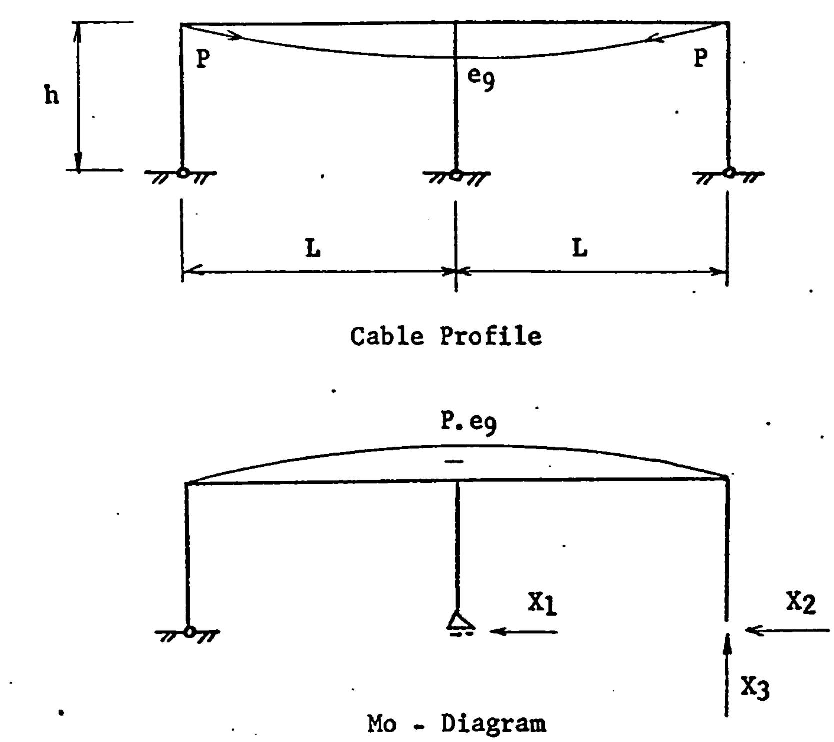


FIG. 16 Parabolic Cable in the Whole Girder with an Eccentricity e_9 at the Middle

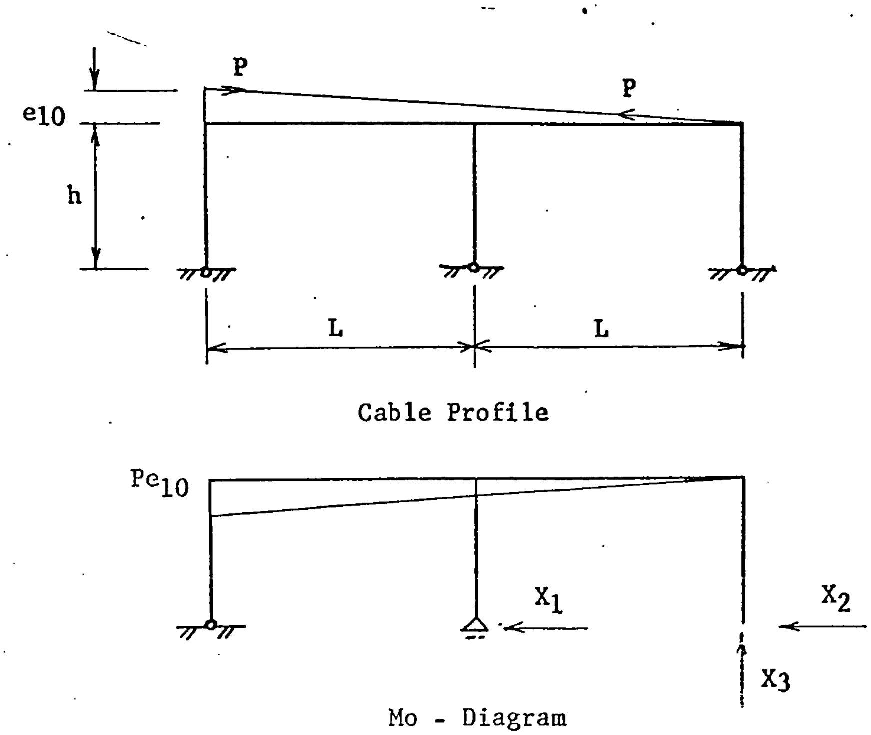


FIG. 17 Linear Cable in the Girder with an Eccentricity e_{10} at the Edge Column

The bending moment is calculated from equation (21) and tables (9.2) and (0.2) give the values of $(M_o + M\ )$ and M_N respectively.

If the frame is composed of two non-equal spans L_1 and L_2, equations (115) (116) and (117) become

$$X_{1M} = \frac{-P.e_9}{3h}\beta\left\{L_1^2L_2(1+7h/3(L_1+L_2)-L_1(1/2+h/L_1+L_2)(L_1^2+L_2^2)-1/6h(L_1^2+L_2^2-L_1L_2)\right. \tag{119}$$

$$X_{2M} = \frac{-P.e_9(L_1+L_2)^2}{3h}\beta\left\{(1/2L_1+1/3h+hL_1)/2(L_1+L_2)-L_1L_2(3/2L_1+h)/(L_1+L_2)^2-L_1^2L_2\right. \\ \left.(L_1+13/3h)/2(L_1+L_2)^3\right\} \tag{120}$$

$$X_{3M} = \frac{P.e_9}{3L_2}\beta\left\{L_1L_2(L_1L_2+1/3h^2)/(L_1+L_2)+hL_1(1/3L_1+L_2)+1/3h^2(L_1+L_2)+4/3hL_1^2L_2\right. \\ \left.(L_1-L_2)/(L_1+L_2)^2\right\} \tag{121}$$

where β is a factor given in equation (45)

The values of the components X_{1N}, X_{2N}, X_{3N} are the same as in equations (22), (23) and (24) respectively.

10. Linear Cable of Triangular Shape in the Whole Girder with an Eccentricity e_{10} at the Edge Column

The bending moment M_o is shown in Fig. (17) and the deformations caused by the prestressing are

$$\delta_{10} = -\ 3Pe_{10}hL/4EI + PL/AE \tag{122}$$

$$\delta_{20} = -\ Pe_{10}hL/EI + 2PL/AE \tag{123}$$

$$\delta_{30} = Pe_{10}L^2/2EI \tag{124}$$

By substituting for these values in equations (3a), (3b) and (3c) and solving them we get

$$X_{1M} = \frac{P.e_{10}L}{4h}\left\{\frac{4/3h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{125}$$

The bending moment is calculated from equation (21) and tables (9.2) and (0.2) give the values of (Mo + M) and M_N respectively.

If the frame is composed of two non-equal spans L_1 and L_2, equations (115) (116) and (117) become

$$X_{1M} = \frac{-P.e_9}{3h}\beta\left\{L_1^2L_2(1+7h/3(L_1+L_2)-L_1(1/2+h/L_1+L_2)(L_1^2+L_2^2)-1/6h(L_1^2+L_2^2-L_1L_2)\right. \tag{119}$$

$$X_{2M} = \frac{-P.e_9(L_1+L_2)^2}{3h}\beta\left\{(1/2L_1+1/3h+hL_1)/2(L_1+L_2)-L_1L_2(3/2L_1+h)/(L_1+L_2)^2-L_1^2L_2\right.$$
$$\left.(L_1+13/3h)/2(L_1+L_2)^3\right\} \tag{120}$$

$$X_{3M} = \frac{P.e_9}{3L_2}\beta\left\{L_1L_2(L_1L_2+1/3h^2)/(L_1+L_2)+hL_1(1/3L_1+L_2)+1/3h^2(L_1+L_2)+4/3hL_1^2L_2\right.$$
$$\left.(L_1-L_2)/(L_1+L_2)^2\right\} \tag{121}$$

where β is a factor given in equation (45)

The values of the components X_{1N}, X_{2N}, X_{3N} are the same as in equations (22), (23) and (24) respectively.

10. Linear Cable of Triangular Shape in the Whole Girder with an Eccentricity e_{10} at the Edge Column

The bending moment Mo is shown in Fig. (17) and the deformations caused by the prestressing are

$$\delta_{10} = -3Pe_{10}hL/4EI + PL/AE \tag{122}$$

$$\delta_{20} = -Pe_{10}hL/EI + 2PL/AE \tag{123}$$

$$\delta_{30} = Pe_{10}L^2/2EI \tag{124}$$

By substituting for these values in equations (3a), (3b) and (3c) and solving them we get

$$X_{1M} = \frac{P.e_{10}L}{4h}\left\{\frac{4/3h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{125}$$

$$X_{2M} = \frac{P.e_{10}L}{4h} \left\{ \frac{1/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{126}$$

$$X_{3M} = -\frac{Pe_{10}}{2L} \left\{ \frac{h^2 + hL}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{127}$$

and the values of the components X_{1N}, X_{2N} and X_{3N} are the same as in equations (17), (18.a) and (19.a).

The matrix form for the components X_M is:

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} -3/4 \\ -y \\ +1/2 \end{vmatrix} Pe_{10}/L \tag{128}$$

and the one for X_N is given in equation (20). Tables (10.1) and (0.1) give the values of X_M and X_N respectively.

The bending moment is calculated from equation (21) and tables (10.2) and (0.2) give the values of $(Mo + M_M)$ and M_N respectively.

Note:

Comparing the two tables (10.2) and (2.2) giving the values of $(Mo + M_M)$ we notice that they are identical. This means that the cable of triangular shape with an eccentricity at the edge column give the same value of $(Mo + M_M)$ whether this cable is in the first span only or in the whole girder.

If the frame has two non-equal spans L_1 and L_2 equations (125), (126) and (127) become

$$X_{1M} = \frac{Pe_{10}}{4h} \beta \left(1/3hL_1^2 + hL_1L_2 + 1/2L_1^2 L_2 + 1/2L_1L_2^2\right) \tag{129}$$

$$X_{2M} = \frac{Pe_{10}}{4h}\,\beta\,(1/3hL_1^2 + 1/2L_1^2 L_2) \qquad (130)$$

$$X_{3M} = \frac{-Pe_{10}}{2L_2}\,\beta\left\{\frac{1/3h^2(L_1+2L_2)-1/3h(L_1^2-L_2^2-3L_1L_2)-1/2L_1L_2(L_1-L_2)}{(1-h/L_1+L_2)}\right\} \qquad (131)$$

where β is a factor given in equation (45)

The values of the components X_{1N}, X_{2N} and X_{2N} are the same as in equations (22), (23) and (24) respectively.

11a. Linear Cable of Triangular Shape in the Edge Column with an Eccentricity e11 at the Top of the Column

The bending moment Mo and the thrust No are shown in Fig. (18). The deformation caused by the prestressing are

$$\delta_{10} = -\ Pe_{11}h^2/3EI \qquad (132)$$

$$\delta_{20} = -\ PE_{11}h^2/3EI \qquad (133)$$

$$\delta_{30} = Ph/AE \qquad (134)$$

The values of the reaction components X_M are:

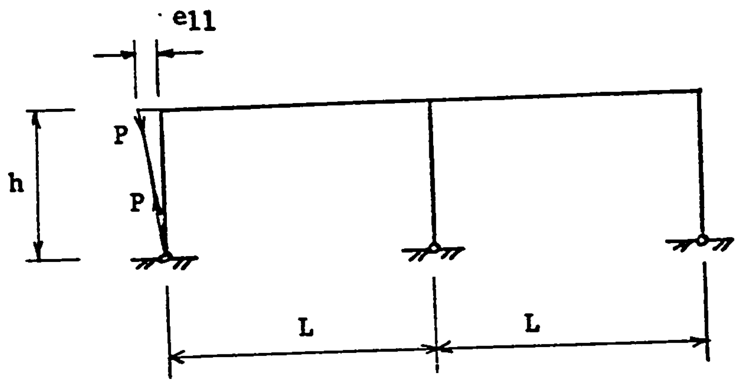
$$X_{1M} = 1/3Pe_{11}\left\{\frac{2/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (135)$$

$$X_{2M} = 1/3Pe_{11}\left\{\frac{2/3h + 3/4L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (136)$$

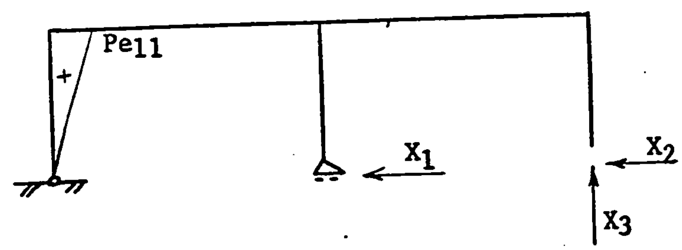
$$X_{3M} = \frac{Pe_{11}h}{3L}\left\{\frac{3/2h + 3/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (137)$$

and the values of the components X_N are

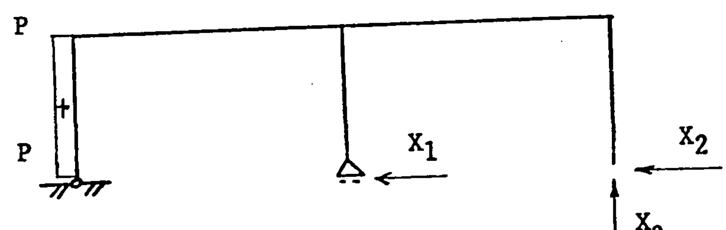
$$X_{1N} = 0 \qquad (138)$$



Cable Profile



Mo - Diagram



Mo - Diagram

FIG.18 Cable in the Edge Column with an Eccentricity e_{11} at the Top of the Column

$$X_{2N} = -\frac{3Pi^2}{2L}\left\{\frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \quad (139)$$

$$X_{3N} = -\frac{Pi^2h}{L^3}\left\{\frac{h^2 + 4hL + 3L^2}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \quad (140)$$

The matrix form for X_M is

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = -\begin{vmatrix} -1/3y^2 \\ -1/3y^2 \\ 0 \end{vmatrix} P.e_{11}/L \quad (141)$$

and the one for X_N

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1N} \\ X_{2N} \\ X_{3N} \end{vmatrix} = -\begin{vmatrix} 0 \\ 0 \\ y \end{vmatrix} P/(L/i)^2 \quad (142)$$

Tables (11.1) and (11-2) give the values of X_M and X_N respectively.

The bending moment is calculated from equation (21) and tables (11.3) and (11.4) give the values of $(Mo + M_M)$ and M_N respectively.

If the frame has two non-equal spans L_1 and L_2, equations (135), (136) and (137) become

$$X_{1M} = 1/3Pe_{11}\ \beta\ (1/3hL_1 + 1/3hL_2 + 1/4L_1L_2 + 1/4L_2^2) \quad (143)$$

$$X_{2M} = 1/3Pe_{11}\ \beta\ (1/3hL_1 + 1/3hL_2 + 3/4L_1L_2) \quad (144)$$

$$X_{3M} = \frac{Pe_{11}h}{3L_2}\ \beta\ (hL_1 + 1/2hL_2 + 3/2L_1L_2) \quad (145)$$

The values of the components X_N are

$$X_{1N} = - \frac{Pi^2 h}{2L_2} \beta \ (L_1 - L_2) \tag{146}$$

$$X_{2N} = - \frac{Pi^2}{L_2} \beta \ (1/2hL_1 + hL_2 + 3/2L_1L_2) \tag{147}$$

$$X_{3N} = - \frac{Pi^2 h}{L_2} \beta \ (h^2 + 2hL_1 + 3L_1L_2 + 2hL_2) \tag{148}$$

where β is a factor given in equation (45)

These values computed, the bending moment is then calculated from equation (21).

11b. Parabolic Cable in the Edge Column with an Eccentricity e at the Middle

The deformations at the supports caused by the applied moment Mo are:

$$\delta_{10} = P.eh^2/3EI \tag{149}$$

$$\delta_{20} = Peh^2/3EI \tag{150}$$

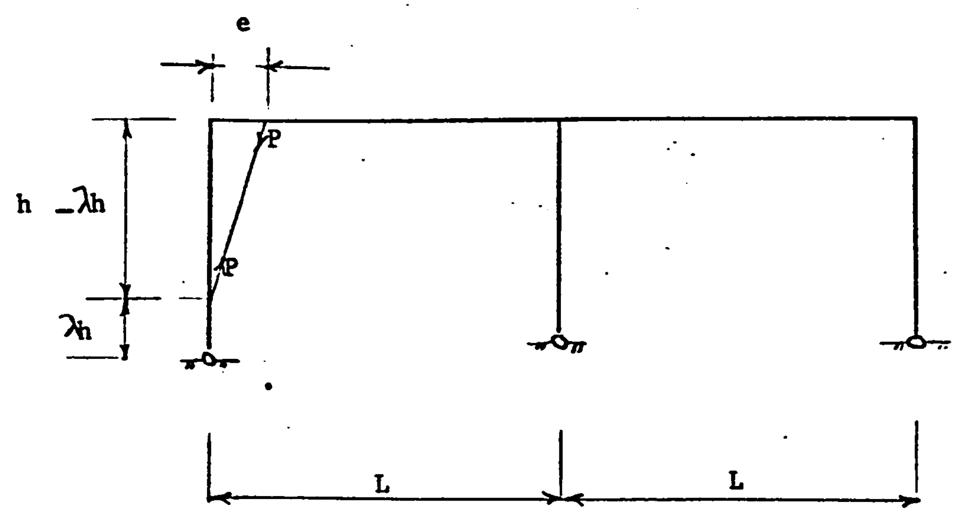
$$\delta_{30} = Ph/AE \tag{151}$$

These deformations are identical to the deformations computed in case (11.a). Therefore, the prestressing values are the same except that the value of Mo in equation (21) giving the prestressing moment is different. Tables (11.5) and (11.7) give the values of X_M and X_N respectively while tables (11.6) and (11.4) give the values of M_M and M_N.

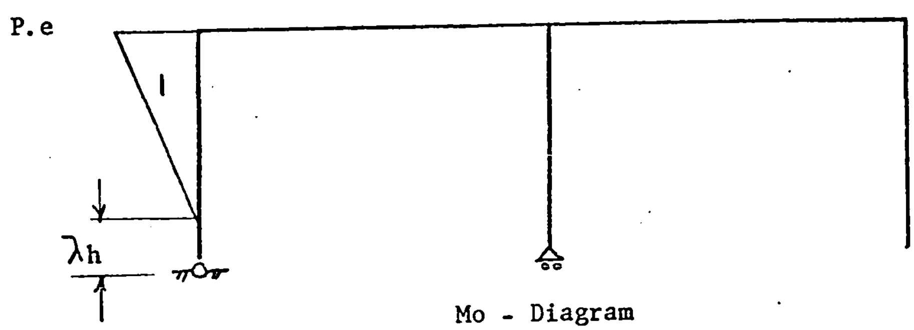
11c. Linear Cable of Triangular Shape in the Edge Column with an Intermediate Anchorage at a Distance λ h from the support (Fig. 19)

The deformations at the supports caused by the applied moment are:

$$\delta_{10} = (1-\lambda)(1/3+1/6\lambda)Peh^2/EI \tag{152}$$



Cable Profile



Mo - Diagram

FIG. 19 Linear Cable in the Edge Column with an Eccentricity e at the Top of the Column and Anchored at a Distance h from the support

$$\delta_{20} = (1-\lambda)(1/3+1/6\lambda)Peh^2/EI \tag{153}$$

$$\delta_{30} = Ph(1-\lambda)/AE \tag{154}$$

The values of the components X_M are

$$X_{1M} = -(1-1/2\lambda-1/2\lambda^2)\,\frac{Pe}{3}\left\{\frac{2/3h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{155}$$

$$X_{2M} = -(1-1/2\lambda-1/2\lambda^2)\,\frac{Pe}{3}\left\{\frac{2/3h + 3/4L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{156}$$

$$X_{3M} = -(1-1/2\lambda-1/2\lambda^2)\,\frac{Peh}{3L}\left\{\frac{1/2h + 1/2L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{157}$$

and the values of the components X_N are

$$X_{1N} = 0 \tag{158}$$

$$X_{2N} = -3Pi^2(1-\lambda)/2L\left\{\frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{159}$$

$$X_{3N} = -Pi^2h(1-\lambda)/L^3\left\{\frac{h^2 + 4hL + 3L^2}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \tag{160}$$

The matrix form of the component X_M is

$$\left| A \right| \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} 1/3(1 - 1/2\lambda - 1/2\lambda^2) \\ 1/3(1 - 1/2\lambda - 1/2\lambda^2) \\ 0 \end{vmatrix} P.e/L \tag{161}$$

and the one of X_N is

$$\left| A \right| \begin{vmatrix} X_{1N} \\ X_{2N} \\ X_{3N} \end{vmatrix} = - \begin{vmatrix} 0 \\ 0 \\ y(1-\lambda) \end{vmatrix} P/(L/i)^2 \tag{162}$$

Tables (11.7) and (11.9) give the values of X_M and X_N respectively.

The bending moment is calculated from equation (21) and tables (11.8) and (11.10) give the values of $Mo + M_M$ and M_N respectively.

If the frame has two non-equal spans L_1 and L_2, equations (155), (156) and (157) become

$$X_{1M} = -(1-1/2\lambda-1/2\lambda^2)\,\underline{Pe}\,\beta\,(1/3hL_1+1/3hL_2+1/4L_1L_2+1/4L_2^2) \tag{163}$$

$$X_{2M} = -(1-1/2\lambda-1/2\lambda^2)\frac{Pe}{3}\beta(1/3hL_1+1/3hL_2+3/4L_1L_2) \tag{164}$$

$$X_{3M} = -(1-1/2\lambda-1/2\lambda^2)\frac{Peh}{3L_2}\beta(hL_1+1/2hL_2+3/2L_1L_2) \tag{165}$$

and the values of the components X_N are

$$X_{1N} = -\frac{Pi^2h(1-\lambda)}{2L_2}\beta(L_1-L_2) \tag{166}$$

$$X_{2N} = -\frac{Pi^2(1-\lambda)}{L_2}\beta(1/2hL_1+1/2hL_2+3/2L_1L_2) \tag{167}$$

$$X_{3N} = -\frac{Pi^2h(1-\lambda)}{L_2}\beta(h^2+2hL_1+2hL_2+3L_1L_2) \tag{168}$$

12. Linear Cable of Triangular Shape in the Intermediate Column with an Eccentricity e_{12} at the Top of the Column

The moment Mo and the thrust No are shown in Fig. (20)

The deformations caused by the prestressing are

$$\delta_{10} = Pe_{12}h/3EI \tag{169}$$

$$\delta_{20} = 0 \tag{170}$$

$$\delta_{30} = -2Ph/AE \tag{171}$$

The values of the reaction components X_M are

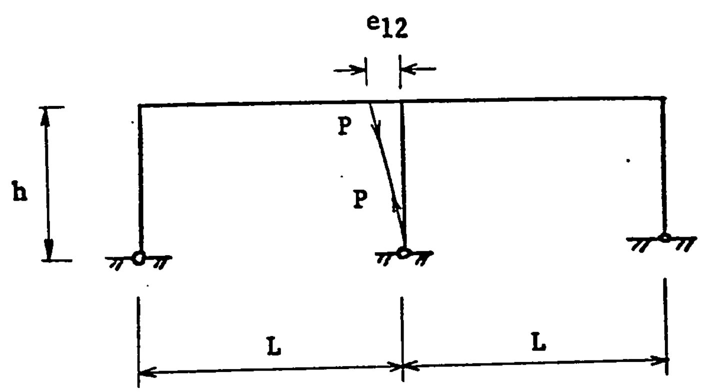
$$X_{1M} = -1/3Pe_{12}\left\{\frac{4/3h+L}{2/3h^2+7/6hL+1/2L^2}\right\} \tag{172}$$

$$X_{2M} = 1/3Pe_{12}\left\{\frac{2/3h+1/2L}{2/3h^2+7/6hL+1/2L^2}\right\} \tag{173}$$

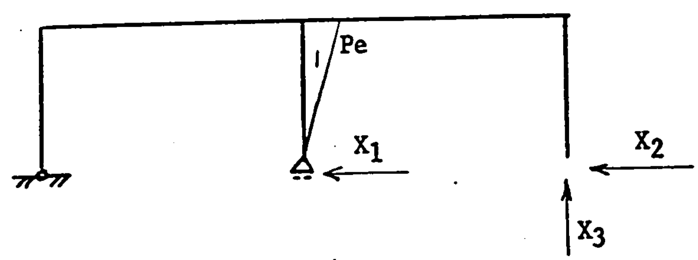
$$X_{3M} = 0 \tag{174}$$

and the values of the components X_N are

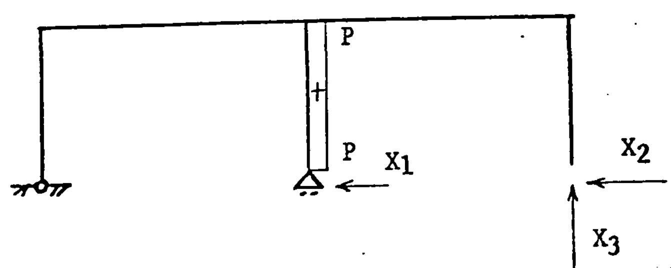
$$X_{1N} = 0 \tag{175}$$



Cable Profile



Mo - Diagram



No - Diagram

FIG.20 Cable in the Intermediate Column with an Eccentricity e_{12} at the Top of the Column

$$X_{2N} = \frac{3Pi^2}{L}\left\{\frac{h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \quad (176)$$

$$X_{3N} = \frac{2Pi^2h}{L^3}\left\{\frac{h^2 + 4hL + 3L^2}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \quad (177)$$

The matrix form for X_M is

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1M} \\ X_{2M} \\ X_{3M} \end{vmatrix} = - \begin{vmatrix} 1/3y^2 \\ 0 \\ 0 \end{vmatrix} P.e12/L \quad (178)$$

and the one for X_N

$$\begin{vmatrix} A \end{vmatrix} \begin{vmatrix} X_{1N} \\ X_{2N} \\ X_{3N} \end{vmatrix} = - \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix} P/(L/i)^2 \quad (179)$$

Tables (12.1) and (12.2) give the values of X_M and X_N respectively.

The bending moment is calculated from equation (21) and tables (12.3) and (12.4) give the values of ($Mo + M_M$) and (M_N) respectively.

If the frame has two non-equal spans L_1 and L_2 equations (172), (173) and (174) become

$$X_{1M} = -1/3P.e12\ \beta\ (2/3hL_1+2/3hL_2+1/4L_1^2+1/4L_2^2+1/2L_1L_2) \quad (180)$$

$$X_{2M} = 1/3Pe12\ \beta\ (1/3hL_1+1/3hL_2+1/4L_1^2+1/4L_1L_2) \quad (181)$$

$$X_{3M} = \frac{-P.e12h}{3L_2^2}\ \beta\ (1/6hL_1L_2- 1/6hL_2^2) \quad (182)$$

The values of the components X_N are

$$X_{1N} = \frac{Pi^2 h}{L_2} \beta\, (L_1 - L_2) \tag{183}$$

$$X_{2N} = \frac{Pi^2}{L_2} \beta\, (hL_1 + 2hL_2 + 3L_1L_2) \tag{184}$$

$$X_{3N} = \frac{2Pi^2 h}{L_2} \beta\, (h^2 + 2hL_1 + 2hL_2 + 3L_1L_2) \tag{185}$$

where is a factor given in equation (45)

13. Other Shapes Developed from the Superposition of Different Cable Profiles

(a) The profile shown in Fig. (21a) is derived from the superposition of the two latter cases (8) and (10). The values of the components X_M are:

$$X_{1M} = Pe_{10}L/4h \left\{ \frac{4/3h + L}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{186}$$

$$X_{2M} = PL/2h \left\{ \frac{h(e_8 + 1/6e_{10}) + L(e_8 + 1/4e_{10})}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{187}$$

$$X_{3M} = -P.h/L \quad \frac{(h + L)(e_8 + 1/2e_{10})}{2/3h^2 + 7/6hL + 1/2L^2)} \tag{188}$$

and the values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (17), (18.a) and (19.a) for the use of the tables, the component X_M is computed by adding the values in table (8.1) to the one in table (10.1). The values of X_N are always computed from table 0.1.

The moment ($Mo + M_M$) is computed by adding the value in table (8.2) to the ones in table (10.2). The values for M_N are given in table (0.2).

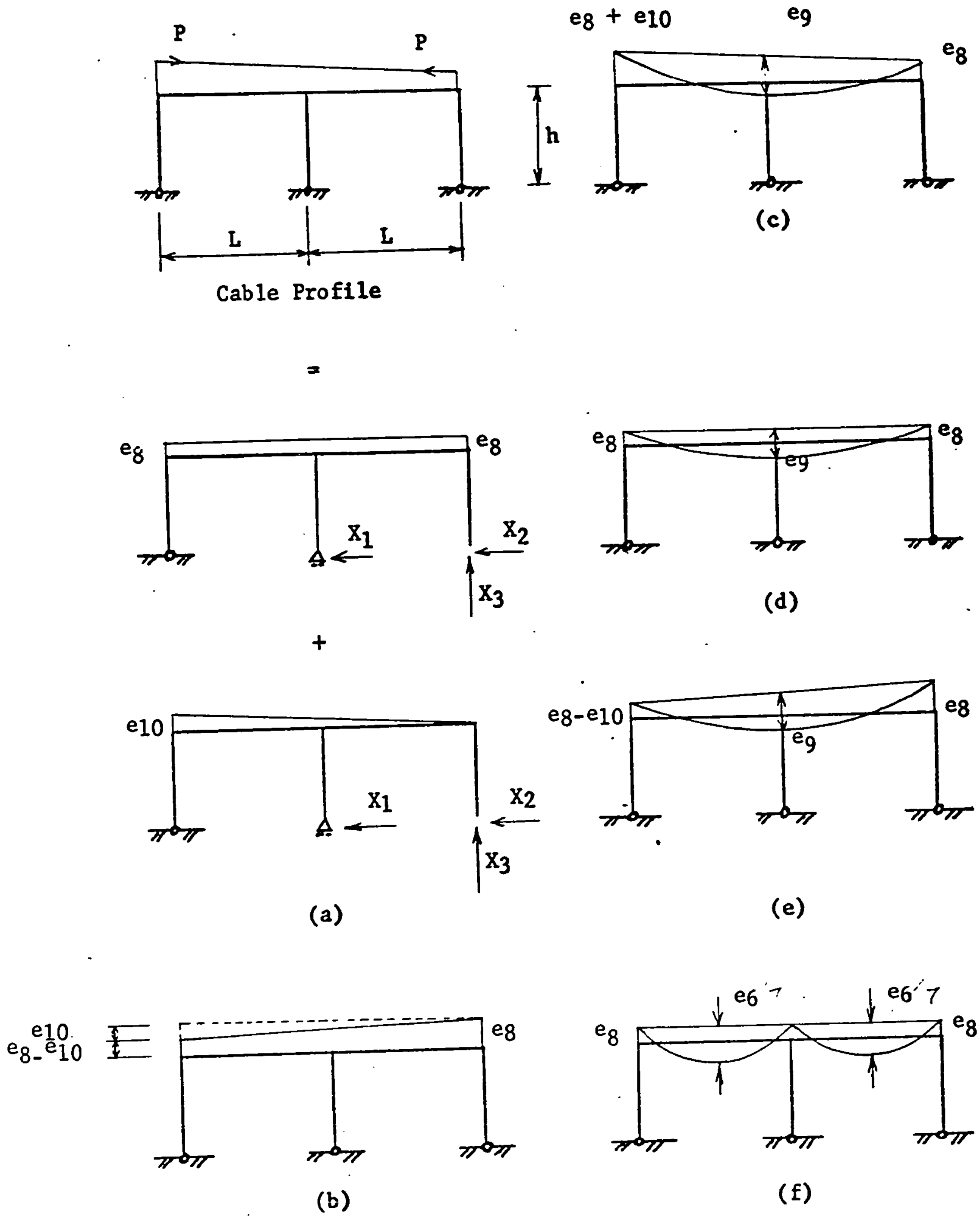


FIG.21 Superposition of Different Cable Profiles

(b) The case presented in Fig. (21) is equivalent to the superposition of the two previous cases (8) and (10) but with a negative sign for the prestressing values in case (10).

(c) The cable profile shown in Fig. (21) is developed from the superposition of the previous cases (8), (9) and (10).

The values of the components X_M are:

$$X_{1M} = Pe_{10}L/4h \left\{\frac{4/3h + L}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (189)$$

$$X_{2M} = PL/2h \left\{\frac{h(e_8 + 1/6e_{10} - 1/6e_9)+L(e_8 + 1/4e_{10} - 1/6e_9)}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (190)$$

$$X_{3M} = -P/L \left\{\frac{h^2(e_8 + 1/2e_{10} - 5/6e_9)+hL(e_8 + 1/2e_{10} - 4/3e_9)-1/2L^2e_9}{2/3h^2 + 7/6hL + 1/2L^2}\right\} \qquad (191)$$

To get the prestressing values for the cable profile shown in Fig. (21)^d we put $e_{10} = 0$ in the previous equations. Fig. (21e) present the profile developed when the eccentricity e_{10} is of negative value.

The values of X_{1N}, X_{2N} and X_{3N} are the same as in equations (17), (18.a) and (19.a). For the use of the tables, apply the superposition for the prestressing values corresponding to each case as explained before.

(d) The profile shown in Fig. (21)^f is developed from the superposition of the profiles in cases (7) and (8).

The values of X_M are

$$X_{1M} = 0 \tag{192}$$

$$X_{2M} = -\ PL/h \left\{ \frac{h(1/3e_7 - 1/2e_8)+L(1/3e_7 - 1/2e_8)}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{193}$$

$$X_{3M} = P/L \left\{ \frac{h^2(2/3e_7 - e_8)+hL(2/3e_7 - e_8)}{2/3h^2 + 7/6hL + 1/2L^2} \right\} \tag{194}$$

(e) The cable profile shown in Fig. (21)g is developed from the superposition of the profiles in cases (3) and (5).

The analysis of the profile in case (5) showed that the moment caused by prestressing was equal to M_N since the value of $(Mo + M_M) = 0$. This means that the eccentricity e_5 is of no value and the superposition is equivalent to a curved cable in the first span (case 3) and a straight cable coinciding with the centroidal axis (effect of thrust).

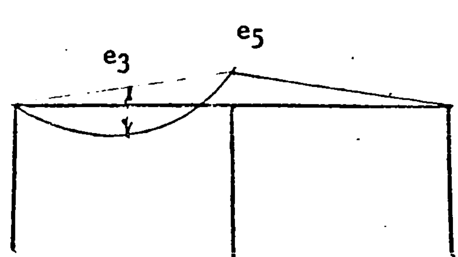


FIG. 21.g Superposition of Different Cable Profiles

CHAPTER IV

CONCLUSIONS

CHAPTER IV

CONCLUSIONS

The influence of prestressing by means of cables with different profiles located in beams and columns has been analysed in the previous chapters. The main conclusions developed by this analysis are:

1. Effect of Axial Deformations Caused by the Thrust on Prestressing Values.

The effect of the axial deformations related to the thrust caused by the prestressing cannot be neglected in frames having a small height h compared to the span L. In practical cases it is advisable to consider the effect of the thrust when analysing the influence of prestressing on a two-bay frame having a ratio h/L equal or less than $1/2$. It is meant by practical cases when the ratio L/i varies between 60 and 240 and when the eccentricity of the cable e is equal or bigger than the radius of gyration i of the member. If for any reason the eccentricity is chosen such as the ratio e/i is very small or close to zero, the secondary moment in the frame resulting from prestressing will be caused mainly by the axial deformations related to the thrust.

2. Relation Between the Line of Thrust and a Linear Cable in the Girder.

Two cable profiles having the same end anchorage points and differing from each other only with regard to the positions of their respective points of intersection with the verticals through the intermediate column will produce the same bending moment in the frame. This means that the eccentricity of the line of thrust at the intermediate column is independent of the eccentricity e of the cable at that section and depends only on the eccentricity of the cable over the end columns. This is similar to the property of a linear cable in a continuous beam, however, it is to note that the line of thrust in the girder of a continuous frame is not coinciding with the centroidal axis as it is the case in a continuous beam because of the secondary moment caused by the axial deformations related to the thrust.

3. Improvement of Stress Conditions for External Loads by Means of Prestressing:

a. Distributed load on the girder:

The most desirable stress condition for an external distributed load on the girder is obtained by prestressing with a continuous parabolic cable in both spans having an eccentricity e at the middle of each span Fig. 14.

The bending moment is calculated by the same method of virtual work used previously in analysing the prestressing influence on the frame.

The value of the prestressing moment at different cross sections is composed of the two components $Mo + M_M$ and M_N. These values are:

$$M_b = -\frac{2}{3} \; Pe_7 \propto (1/2y + 1/2) + \frac{P}{y(L/i)^2} \propto L(2y + 2) \qquad (195)$$

$$M_{c1} = -\frac{2}{3} \; Pe_7 \propto (y^2 + 3/2y + 1/2) - \frac{P}{y(L/i)^2} \propto L(y + 1) \qquad (196)$$

$$M_{c2} = 0 \tag{197}$$

$$M_{c3} = M_{c1} \tag{198}$$

$$M_e = M_b \tag{199}$$

where $\alpha = \dfrac{1}{2/3y^2 + 7/6y + 1/2}$ (200)

The ratio $M_N/(Mo + M_M) = (i/L)(i/e)\phi y$ (201)

In practical cases when h/L varies between 0.1 and 3.0, ϕy varies consequently between 60 and 0.14. Assuming an average value $L/i = 100$ The ratio $M_N/(Mo + M_M)$ varies between:

6.0 and 0.014	when $e = i/10$
0.6 and 0.0014	when $e = i$
0.222 and 0.00052	when $e = 0.45d = 2.7i$

for $h/L = 0.5$, $L/i = 100$ and $i = e$

$M_N/(Mo + M_M) = 0.12$ at sections b and e

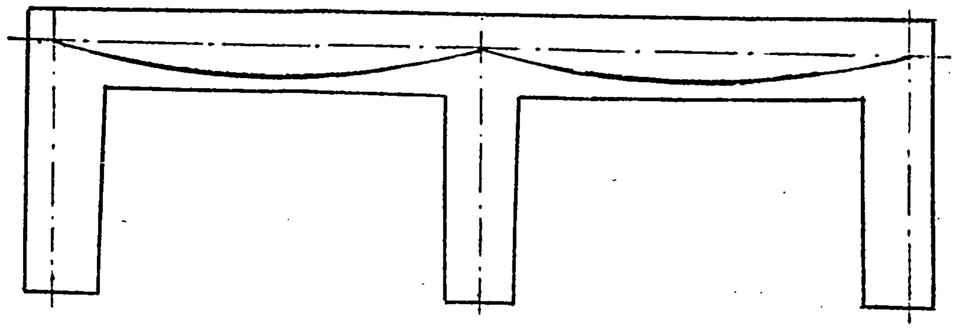
$= 0.03$ at sections c_1 and c_3

therefore M_N/M varies between 0.10 and 0.026.

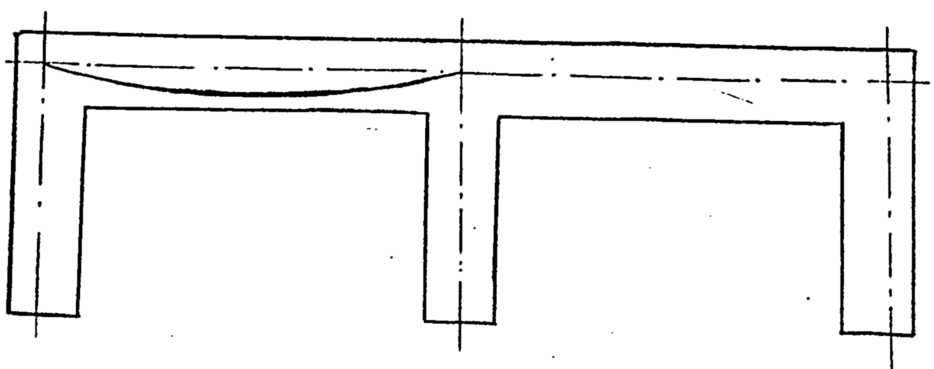
where $M = Mo + M_M + M_N$

From the previous analysis we find that the value of the component M_N cannot be neglected in practical conditions for short frames having a ratio h/L equal or less than 0.5.

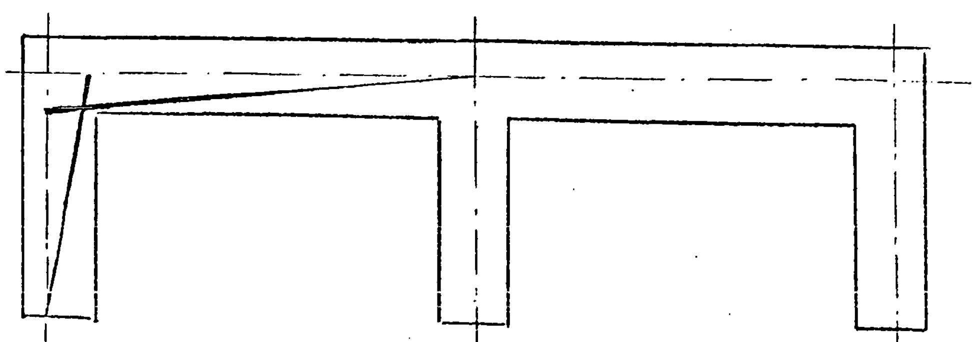
If the moment caused by the prestressing is equal to $(\phi_1 y)$ Pe and the moment caused by the external load is equal to $(\phi_2 y)\, wL^2/8$ the ideal prestressing will happen when $P.e = k\, wL/8$ where k is the ratio $(\phi_2 y)/(\phi_1 y)$. The value of $P.e$ has to change from a section to another according to the corresponding change in the value of k. These values of k are given in table (19) while Fig. 22a shows an example of



a. Distributed load on the girder



b. Distributed load on the first span



c. Lateral concentrated load at the top of the edge column

FIG. 22 Change in the Prestressing Force P

for Different Case of Loading

the variation in the value of P through the prestressed member for the ideal condition of prestressing result, i.e. for the case when the moment caused by the prestressing is identical to the moment caused by the external force but of opposite sign. In most cases the variation in the value of k for different cross-sections is small and the technical complications resulting from varying the value of P through the member can be avoided by using an average value of k for all the sections. Fig. (23.a) shows the discrepancies between the moment caused by prestressing (dotted line) and the moment caused by an external distributed load on the girder (full line) for a short frame having the ratios $h/L = 0.1$, $L/i = 100$ and by assuming that $e = i$, while Fig. (23.b) shows these discrepancies for a frame with $h/L = 3.0$, $L/i = 100$ and by assuming that $e = i$. The adjustment between the prestressing moment and the external moment can also be done by changing the value of the eccentricity e at the middle. It is to note that the value of the eccentricity cannot be changed from a section to another since the whole analysis was done for a specified cable profile, parabolic in this case.

b. Distributed load on one span.

The value of the external moment in this case is given in table (13). The most desirable stress condition is obtained by prestressing with a parabolic cable in the loaded span Fig. (10). The ideal case of prestressing can be obtained when the value of Pe is equal to $k\ wL2/8$. Table (20) give these values of k for different section and Fig. (22.b) h/L = 0.1 k(average) = 0.98

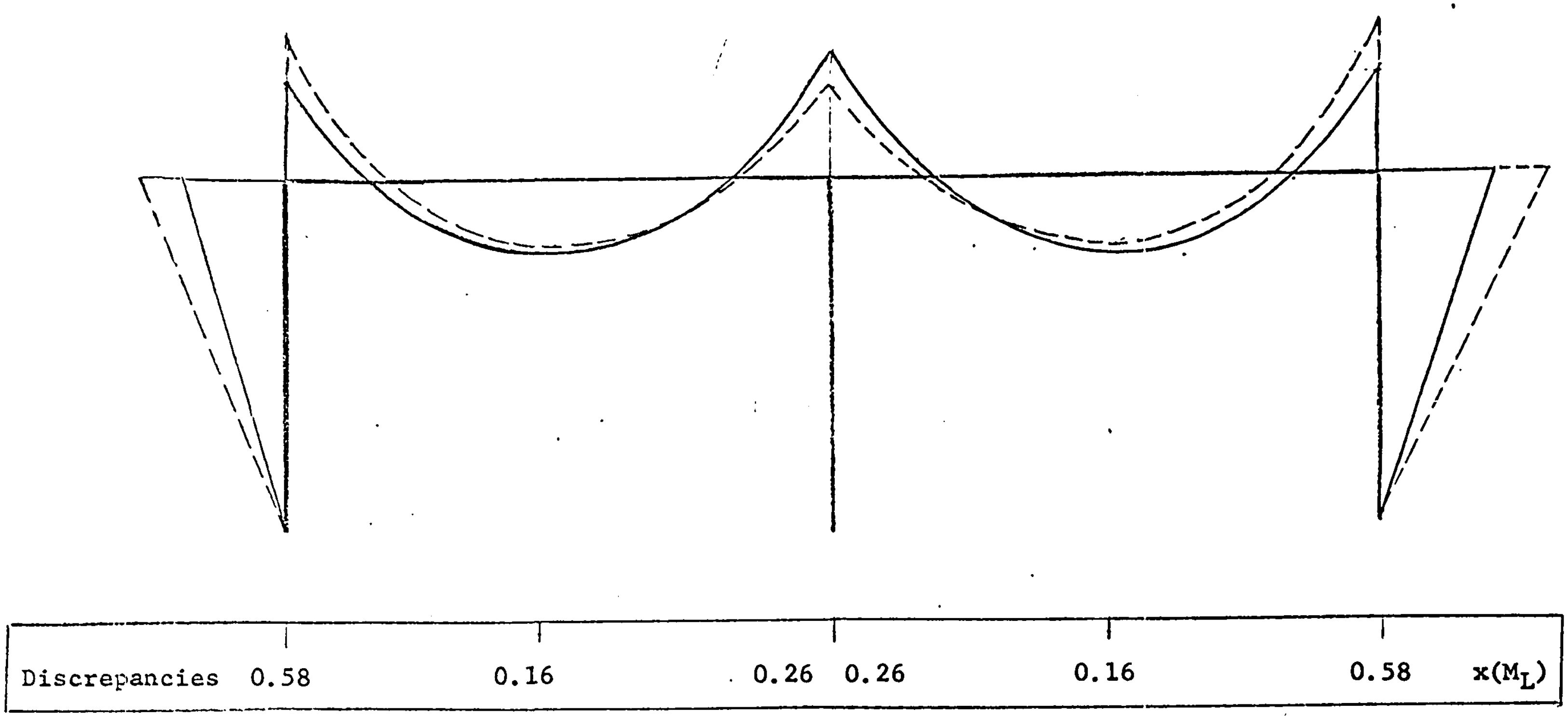
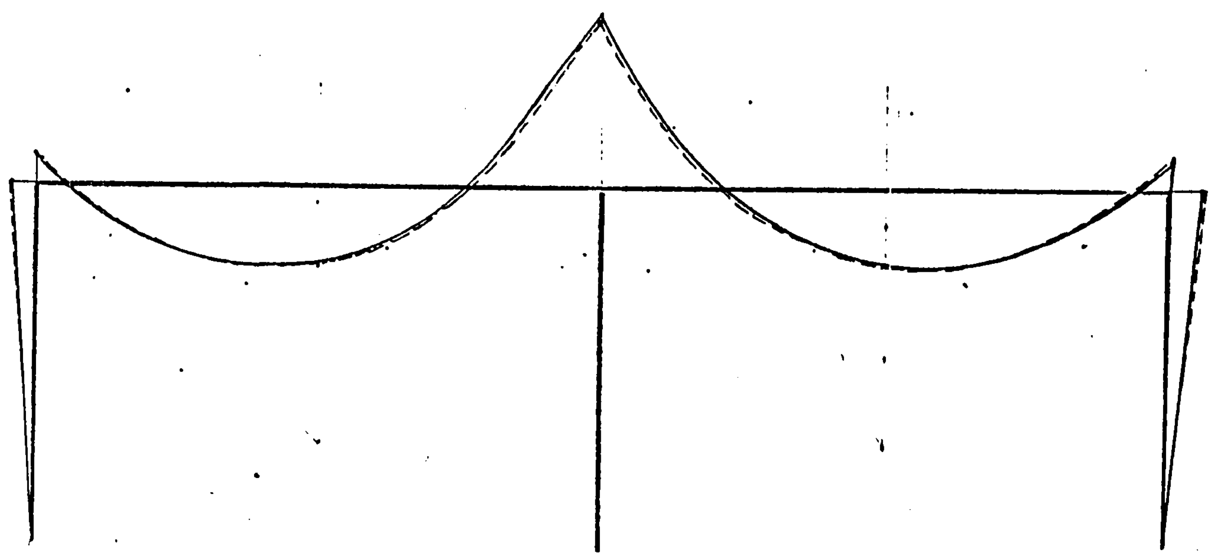


FIG.23.a Discrepancies Between Prestressing Moment and External Moment in the Case of a Vertical Distributed Load on the Girder.

h/L = 3.0 k(average) = 1



Discrepancies	0.02	0.005	0.03	0.03	0.005	0.02	$x(M_L)$

FIG.23.b Discrepancies Between Prestressing Moment and External Moment in the Case of a Vertical Distributed Load on the Girder.

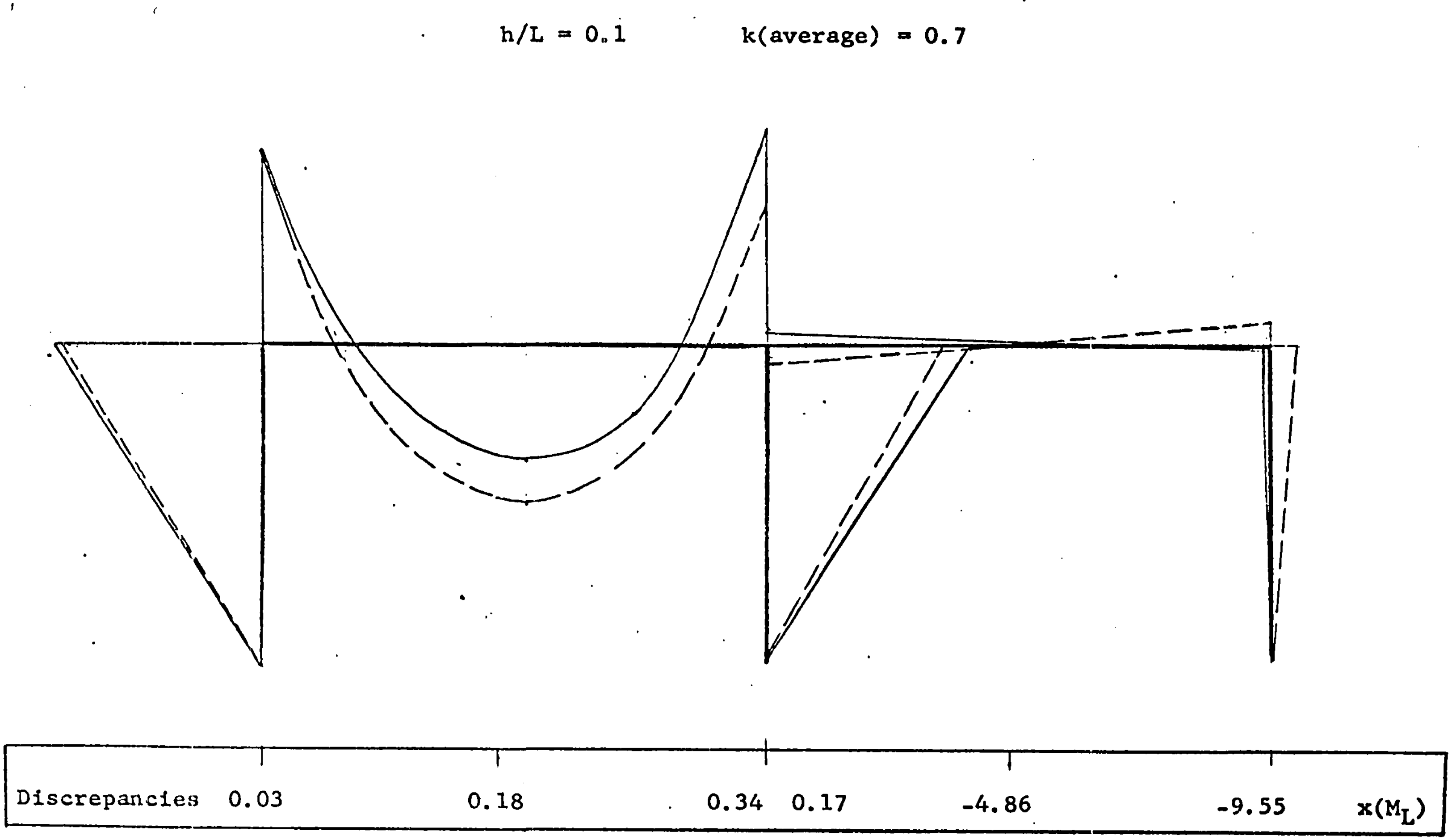


FIG. 24.a Discrepancies Between Prestressing Moment and External Moment in the Case of Vertical Distributed Load on the First Span.

$h/L = 3.0$ $k(\text{average}) = 1$

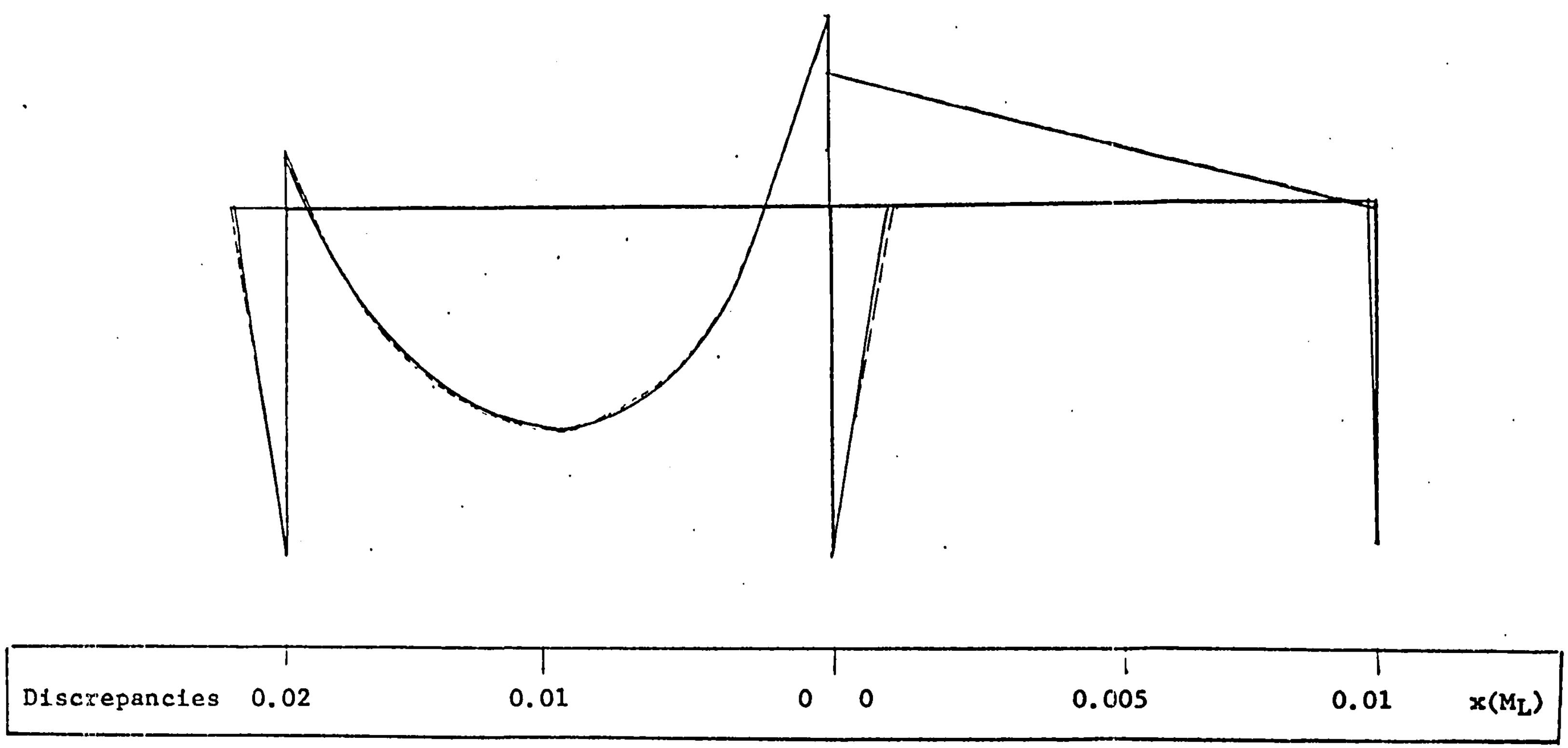


FIG. 24.b Discrepancies Between Prestressing Moment and External Moment in the Case of Vertical Distributed Load on the First Span.

shows the variation in the value of P corresponding to the change in the value of k while Fig. 24.a and 24.b show the discrepancies between the prestressing moment (dotted line) and the external moment (full line) for a frame having a ratio $h/L = 0.1$ and 0.3 respectively. Assuming an average value for k and taking $L/i = 100$ and $i = e$.

c. Lateral distributed load acting on the edge column.

The bending moment caused by this loading case is computed in table (15). To select the cable profile that gives the most desirable stress condition, we draw the moment diagram for the main system (i.e. the statically determinate system) caused by the external load, A cable having the same profile as this moment diagram will produce a final moment due to prestressing similar in shape to the moment caused by the external load, this profile is shown in Fig. (25) and the prestressing reactions and moments can be calculated by using the principle of superposition. Table (15) gives the values of this prestressing moment for different values h/L. The ideal results of prestressing are obtained when $Pe = k\,wL^2/8$ where k is defined in case (a).

Fig. (22)f shows an example of the variation of P through the prestressed member corresponding to the change in the value of k from a section to another while Fig. (28)a and (28)b shows the discrepancies between the prestressed moment (dotted line) and the external moment (full line) when $h/L = 0.1$ and 3.0 respectively, assuming $L/i = 100$, $i = e$ and using an average value of k.

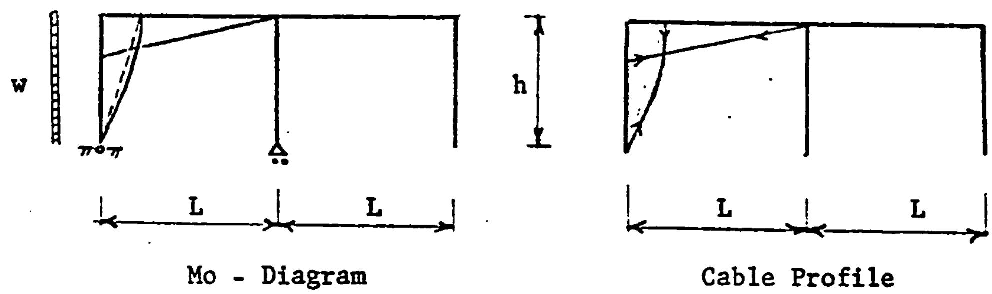


FIG. 25 Prestressing for Lateral Distributed Load

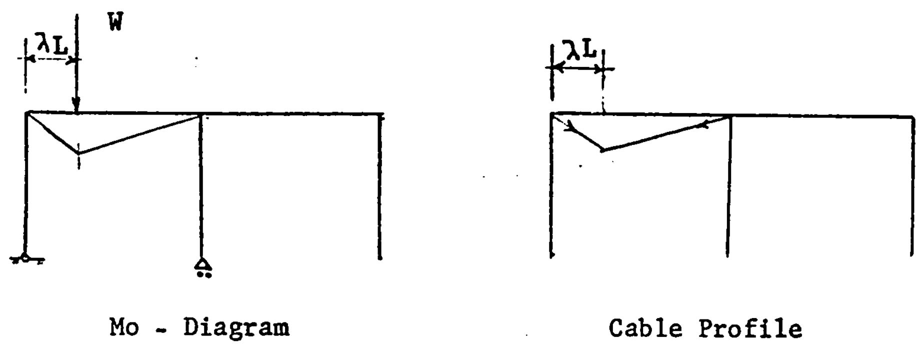


FIG. 26 Prestressing for Vertical Load on the First Span

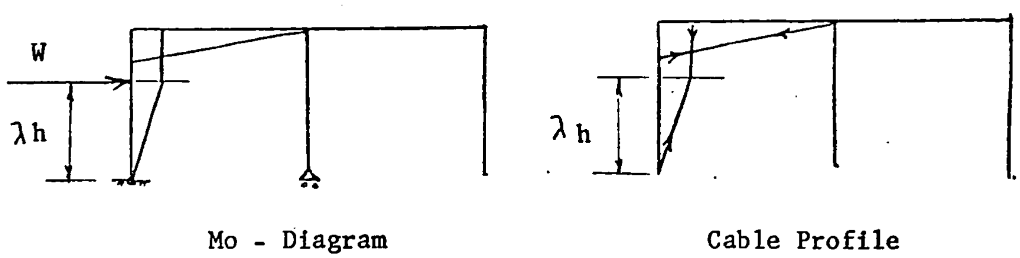


FIG. 27 Prestressing for Lateral Concentrated Load

h/L = 0.1   k = 0.05

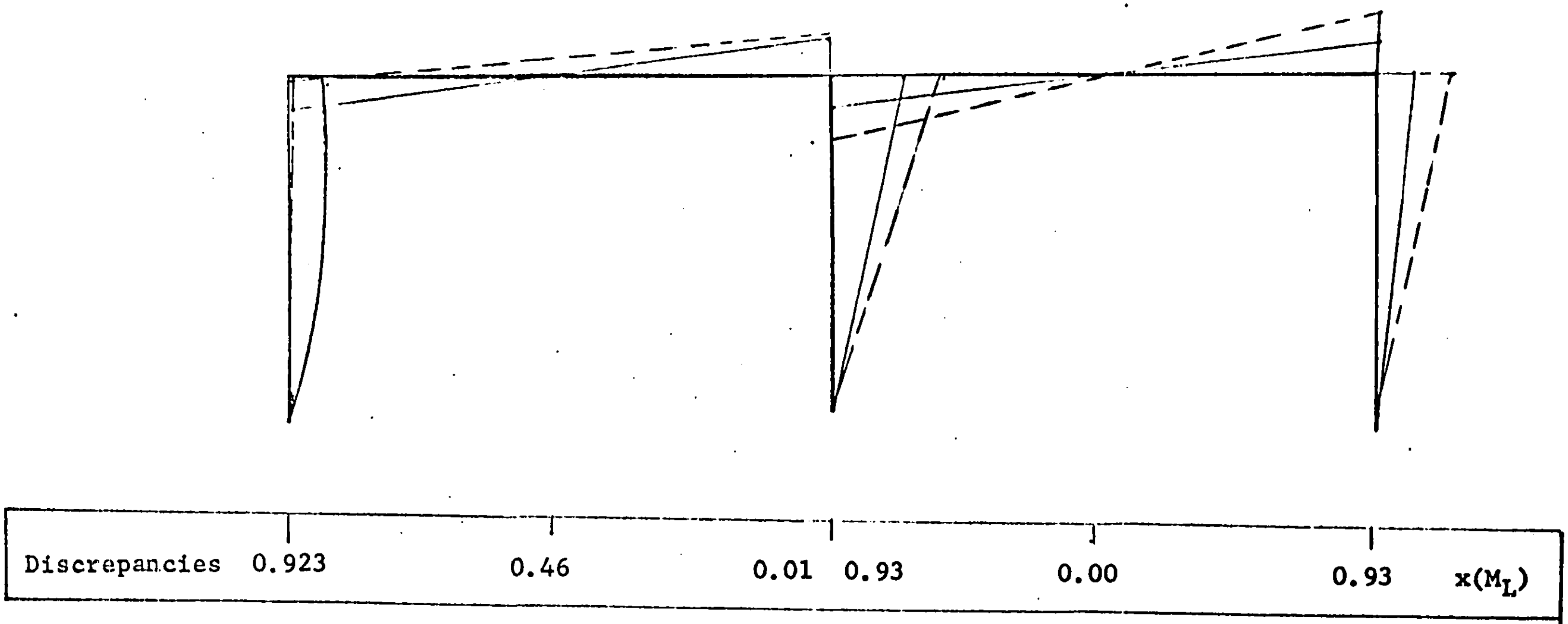


FIG. 28. a Discrepancies Between Prestressing Moment and External Moment in the Case of a Lateral Concentrated Load Acting at the Top of the Column.

h/L = 3.0   k(average) = 39

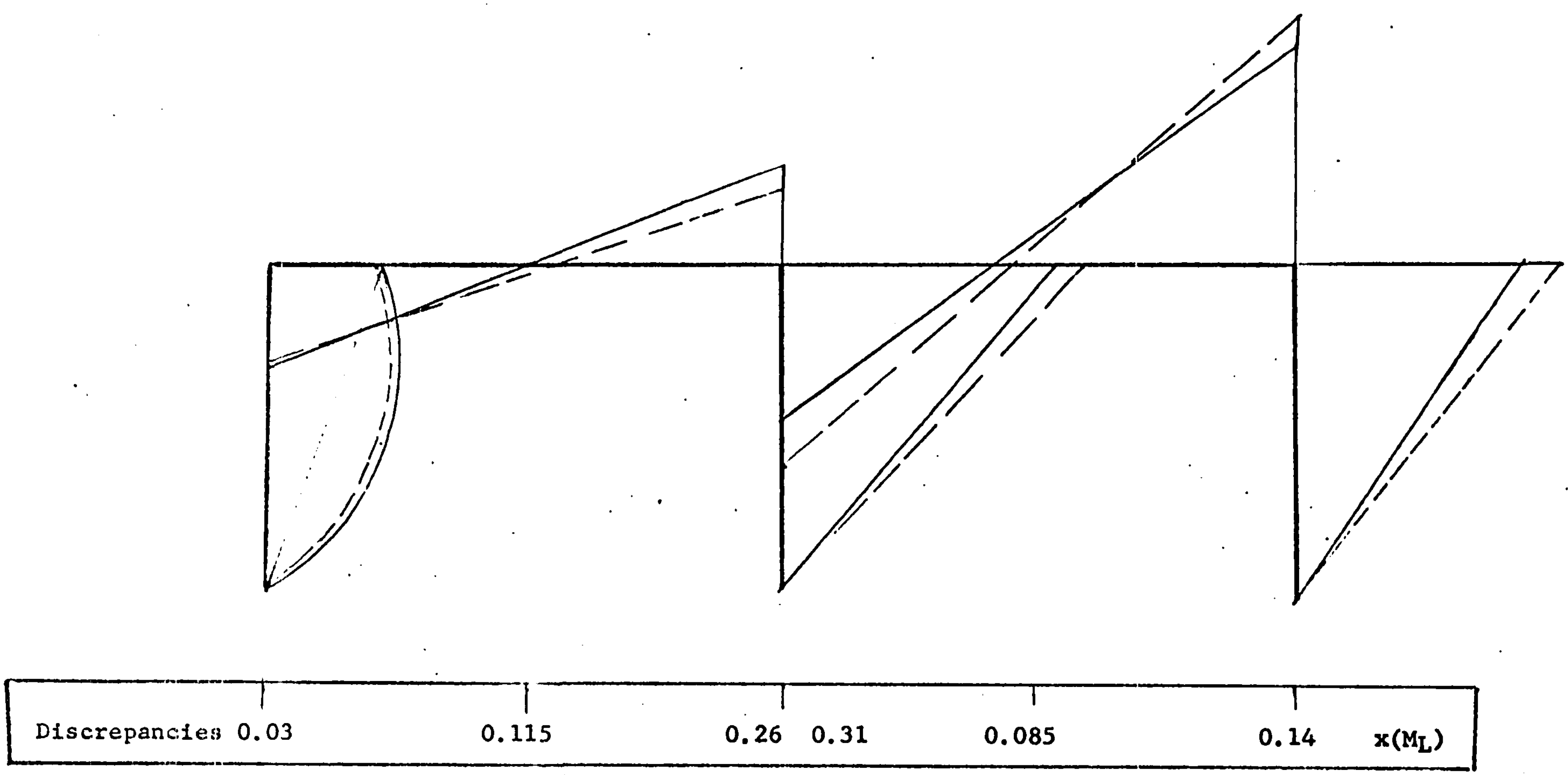


FIG. 28b Discrepancies Between Prestressing Moment and External Moment in the Case of Lateral Distributed Load on the Edge Column.

d. Concentrated load acting on the first span at a distance λL from the edge column.

The bending moment caused by the loading case is computed in tables (17) and $(17)^a$ for $\lambda = 0.2$ and 0.6 respectively. Using the same method described in case (c) for tracing the prestressed cable, we find that the cable profile shown in Fig. (26) gives the most desirable stress condition for this case of loading. Tables $(24)^a$ and $(24)^b$ give the values of the prestressing moment for $\lambda = 0.2$ and 0.6 respectively. The ideal case of prestressing is obtained when $P = k\ wL/4$ where W is the concentrated external load. Fig. (29) and (29) show the discrepancies between the prestressing moment (dotted line) and the external moment (full line) when $h/L = 0.1$ and 0.3 respectively, assuming $L/i = 100$, $i = e$ and using an average value of k.

e. Lateral concentrated load acting on the edge column at a distance λh from the support.

The bending moment related to this case of loading is computed in tables (16) and $(16)^a$ for $\lambda = 0.4$ and 1.0 respectively. The cable profile giving the most desirable stress condition is shown in Fig. (27).

The prestressing reactions and moments are calculated using the method of superposition and tables (23) and $(23)^a$ give the values of the prestressing moment for $\lambda = 0.4$ and 1.0 respectively. Fig. $(30)^a$ and $(30)^b$ show the discrepancies between the prestressing moment (dotted line) and the external moment (full line) when $H/L = 0.1$ and 0.3 respectively assuming $L/i = 100$, $e = i$ and using an average value of k.

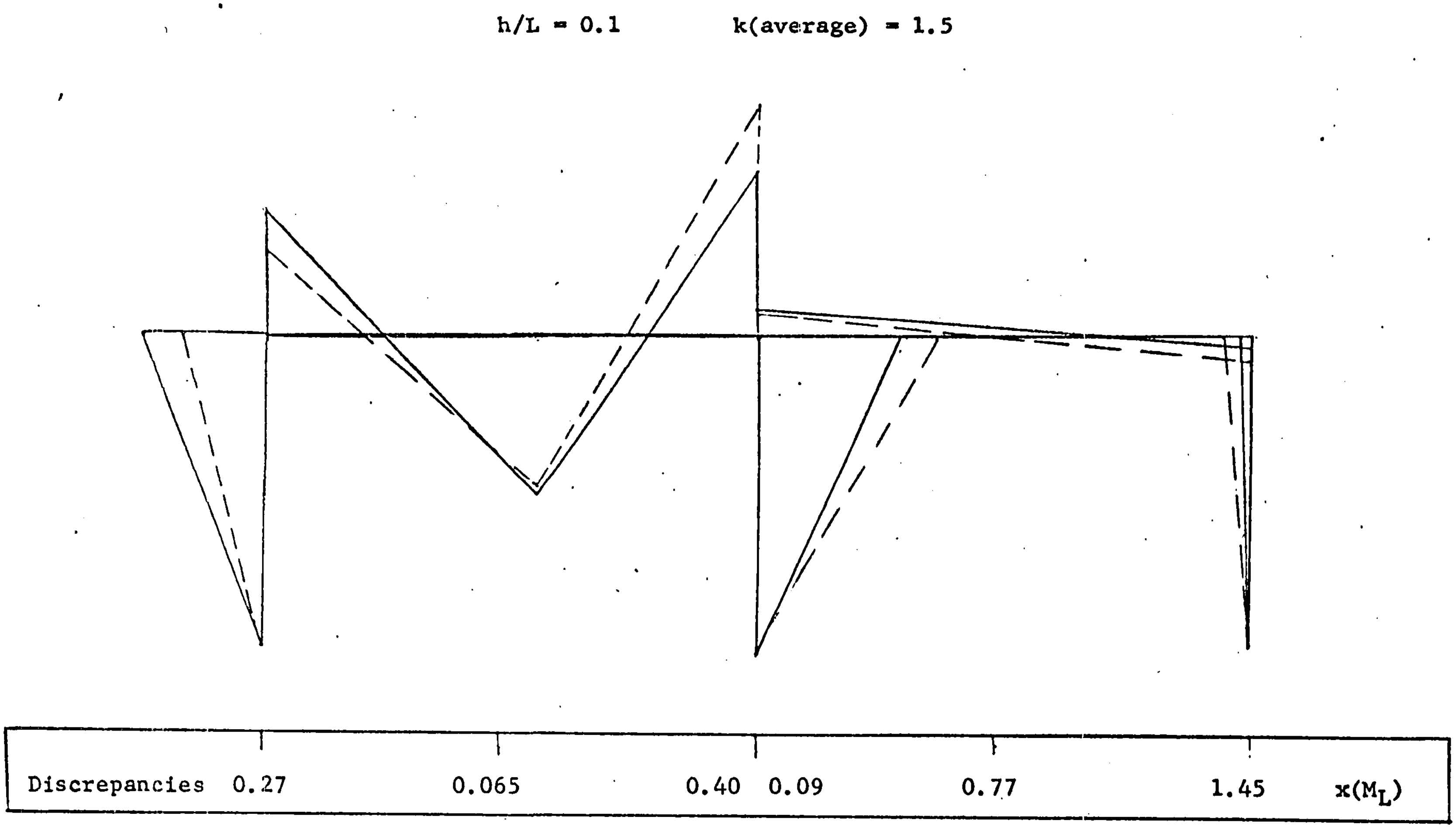
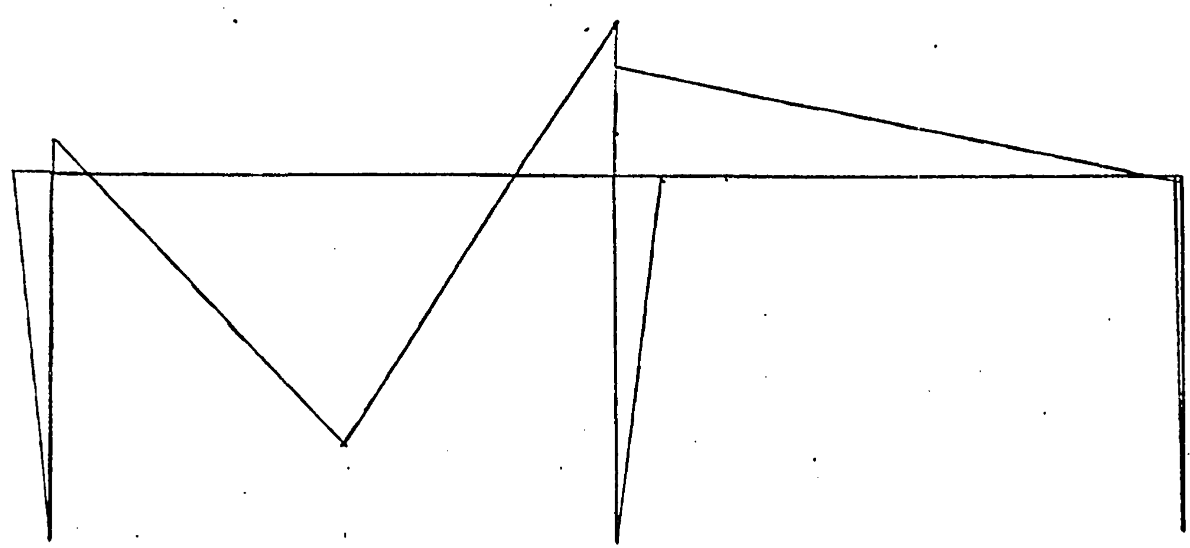


FIG. 29a Discrepancies Between Prestressing Moment and External Moment in the Case of a Vertical Load Acting on the First Span at a Distance = 0.6L from the Edge Column.

h/L = 3.0   k(average) = 0.96



Discrepancies	0.00	0.00	0.00	0.00	0.00	0.00

FIG.29b Discrepancies Between Prestressing Moment and External Moment in the Case of a Vertical Load Acting on the First Span at a Distance 0.6L from the Edge Column.

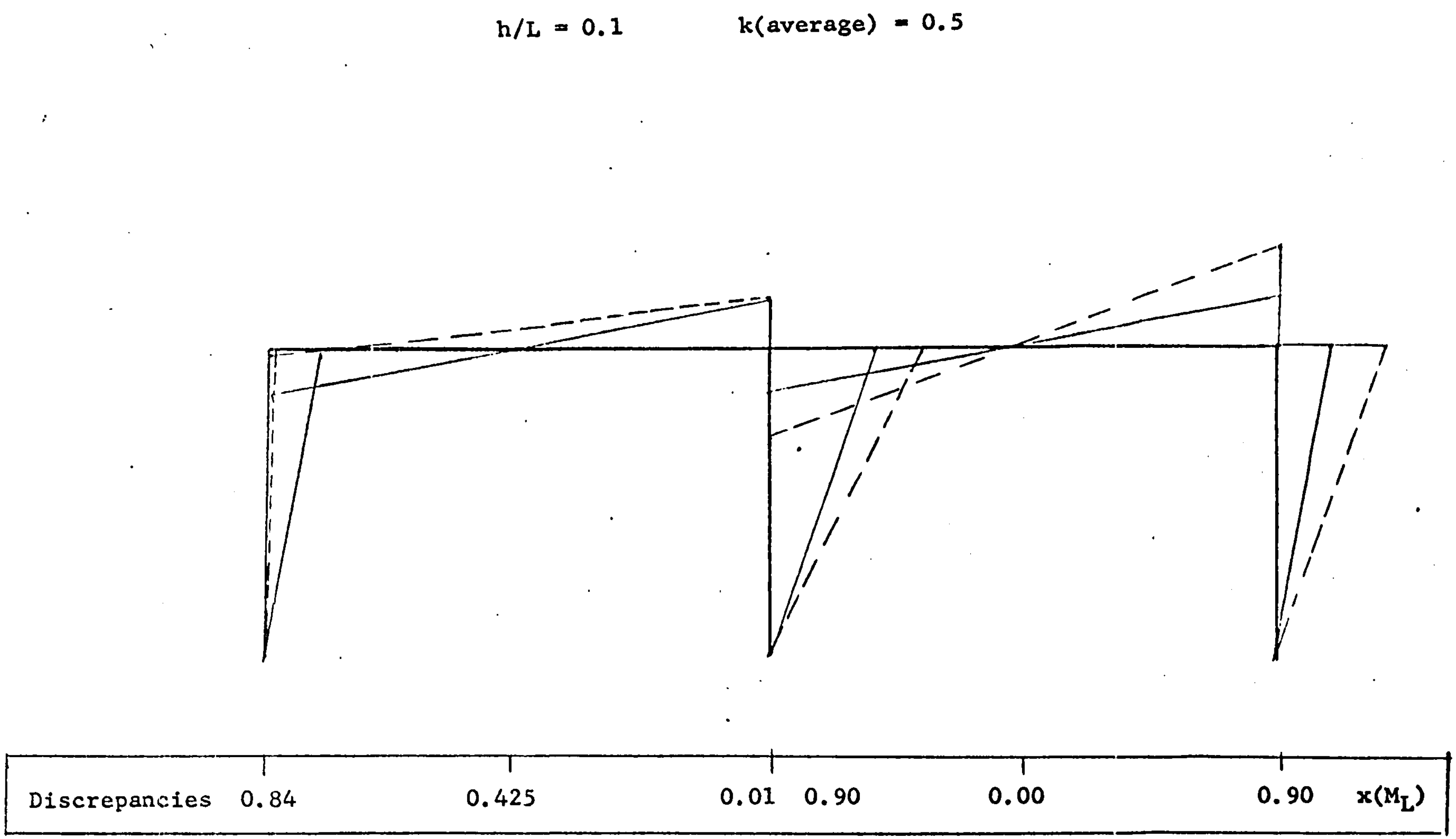


FIG.30a Discrepancies Between Prestressing Moment and External Moment in the Case of a Lateral Concentrated Load Acting at the Top of the Column.

$h/L = 3.0$ $k = 12.5$ $= 1.0$

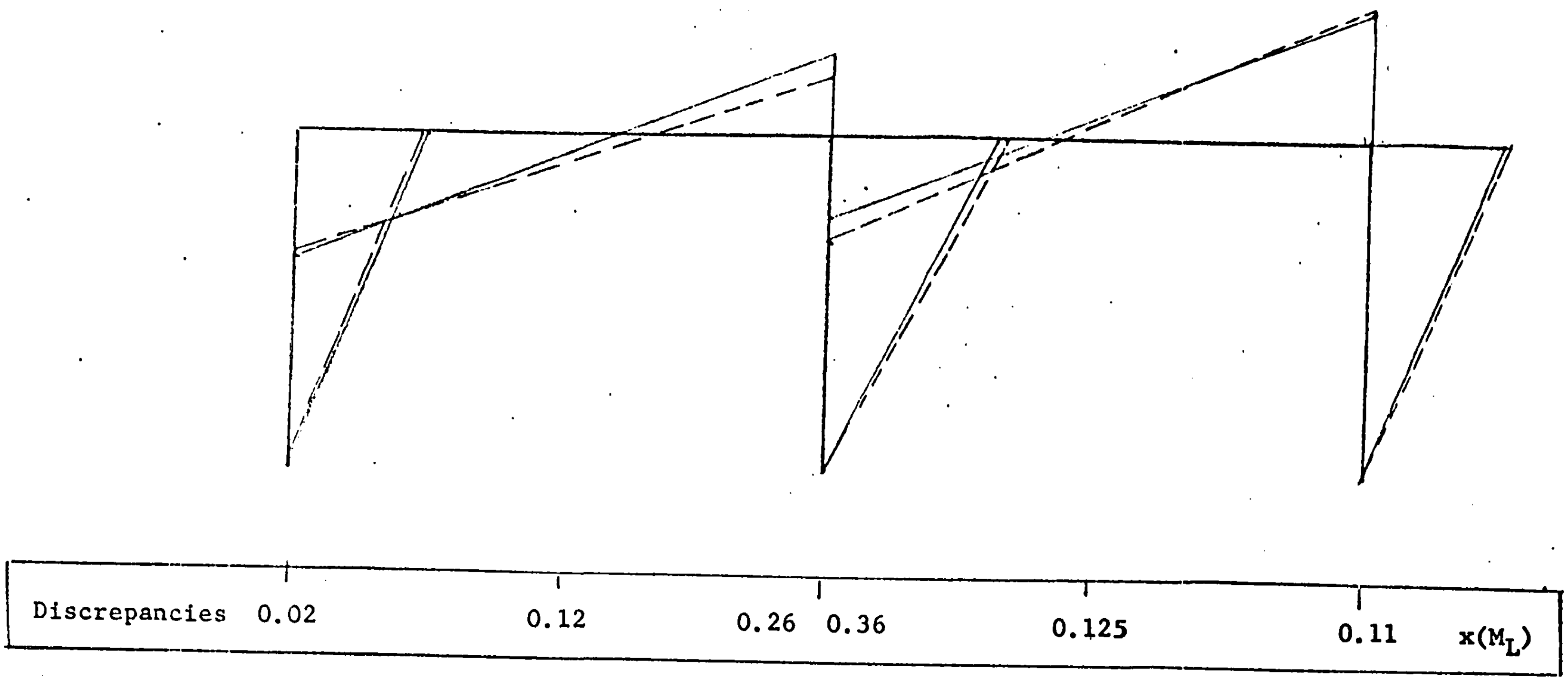


FIG. 30b Discrepancies Between Prestressing Moment and External Moment in the Case of a Lateral Concentrated Load Acting at the Top of the Column.

f. Variation of temperature

The deformations occurring in the frame due to a rise in the temperature produce a bending moment which values are given in table (18). The most desirable stress condition is obtained by prestressing with a cable coinciding with the centroidal axis of the girder. The values of the prestressing moment are given in table (02). The ideal case of prestressing is obtained when $Pe = k\gamma tL$ where k is a factor defined in case (a).

In the previous cases of loading the value of the factor k was varying through the prestressed member. However, in the temperature case, this value of k is constant and equal to 1.

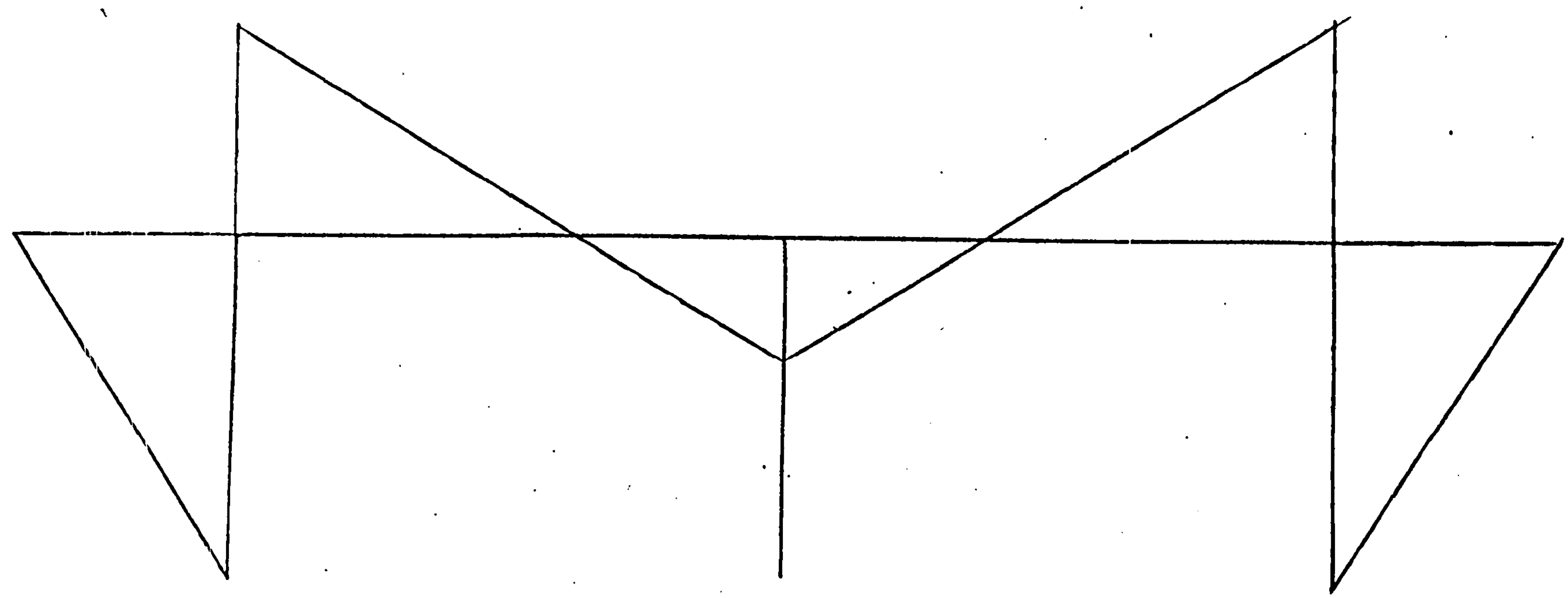
The change in the value of k for the previous cases of loading was related to the fact that the component M is considered in the case of the prestressing moment while this component is neglected in the case of the external moment. Fig. (31) shows the prestressing moment diagram coinciding with the external moment diagram when the value of $k = 1$.

4. Simplified Design Procedure for a Two-Bay Prestressed Frame with Pined Supports Subjected to Different Cases of Loading.

a. The bending moment diagram caused by the external loading case is drawn for the main system i.e. for the statically determined system developed by changing the supports conditions.

b. The cable profile is traced in a manner to have the same shape as the external moment diagram in the main system.

$h/L = 0.1$ $k = 1$



Discrepancies	0.00	0.00	0.00	0.00	0.00	0.00

FIG. 31 Discrepancies Between Prestressing Moment and External Moment in the Case of a Rise in the Temperature.

c. The ratio between the height and the span of the frame is calculated and the slenderness ratio L/i is assumed.

d. The bending moment caused by the external load is calculated by using the practical tables developed in this work or by using the vertical work or any suitable method, this moment will be the form $\Phi_2 y wL^2/8$ $\Phi_2 y\ wL/4$....or $\Phi_2 y \cdot M_L$.

e. The prestressing moment is computed either directly from the tables or by super-imposing the values in one table on the values in other tables. If the frame has a ratio h/L not given in the tables, the analytical equations of the moment calculated in Chapter III will be used. If the frame has two non-equal spans L_1 and L_2, the analytical equations giving the parasitic reactions for a frame with two non-equal spans and developed in Chapter III will be used, then the prestressing moment is calculated from equation 21 in the same chapter.

f. The prestressing value $P.e$ is selected to equal kM_L where k is defined in case 3.a of Chapter III. This adjustment in the value of $P.e$ is done by changing either the value of P or the value of e.

In practical cases of prestressing with a cable having a maximum eccentricity e, the value of e has to be equal or bigger than the value of i in order to keep the value of the thrust component M_N as low as possible.

g. The prestressing force and the maximum eccentricity of the cable being determined, the frame is then designed in the same manner as in the case of statically determined prestressed structures, i.e. to be designed for the most critical stress conditions.

TABLES

TABLE 0-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE GIRDER.

Y	X_{1N}	X_{2N}	X_{3N}
0.10	-0.00031	-352.94140	-52.94125
0.15	0.00000	-148.14810	-33.33334
0.20	0.00001	-78.94740	-23.68422
0.25	-0.00007	-48.00000	-18.00002
0.30	-0.00001	-31.74608	-14.28574
0.40	-0.00002	-16.30434	-9.78261
0.50	-0.00000	-9.60000	-7.20000
0.60	-0.00000	-6.17284	-5.55555
0.70	0.00000	-4.22238	-4.43350
0.80	0.00000	-3.02420	-3.62904
0.90	-0.00000	-2.24467	-3.03031
1.00	-0.00000	-1.71428	-2.57143
1.25	-0.00000	-0.96000	-1.80000
1.50	-0.00000	-0.59259	-1.33333
1.75	-0.00000	-0.39184	-1.02857
2.00	-0.00000	-0.27273	-0.81818
2.25	-0.00000	-0.19753	-0.66667
2.50	-0.00000	-0.14769	-0.55385
3.00	-0.00000	-0.08889	-0.40000
3.50	-0.00000	-0.05762	-0.30252
4.00	-0.00000	-0.03947	-0.23684
5.00	-0.00000	-0.02087	-0.15652

MULTIPLICATOR = $P/(L/i)^2$

TABLE 0-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE GIRDER.

Y	M_{bN}	M_{c1N}	M_{c2N}	M_{c3N}	M_{eN}
0.10	35.29416	-17.64709	0.00003	-17.64711	35.29414
0.15	22.22221	-11.11113	-0.00000	-11.11113	22.22221
0.20	15.78948	-7.89474	-0.00000	-7.89474	15.78948
0.25	12.00002	-6.00000	0.00002	-6.00002	12.00000
0.30	9.52382	-4.76191	0.00000	-4.76192	9.52382
0.40	6.52174	-3.26087	0.00001	-3.26088	6.52173
0.50	4.80000	-2.40000	0.00000	-2.40000	4.80000
0.60	3.70370	-1.85185	0.00000	-1.85185	3.70370
0.70	2.95567	-1.47783	-0.00000	-1.47783	2.95567
0.80	2.41936	-1.20968	-0.00000	-1.20968	2.41936
0.90	2.02020	-1.01010	0.00000	-1.01010	2.02020
1.00	1.71428	-0.85714	0.00000	-0.85714	1.71428
1.25	1.20000	-0.60000	0.00000	-0.60000	1.20000
1.50	0.88889	-0.44444	0.00000	-0.44444	0.88889
1.75	0.68571	-0.34286	0.00000	-0.34286	0.68571
2.00	0.54545	-0.27273	0.00000	-0.27273	0.54545
2.25	0.44444	-0.22222	0.00000	-0.22222	0.44444
2.50	0.36923	-0.18462	0.00000	-0.18462	0.36923
3.00	0.26667	-0.13333	0.00000	-0.13333	0.26667
3.50	0.20168	-0.10084	0.00000	-0.10084	0.20168
4.00	0.15789	-0.07895	0.00000	-0.07895	0.15789
5.00	0.10435	-0.05217	0.00000	-0.05217	0.10435

MULTIPLICATOR = Pi^2/L

TABLE 1-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_1 AT THE INTERMEDIATE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	4.54545	-2.27272	-0.50000
0.15	2.89855	-1.44927	-0.50000
0.20	2.08333	-1.04167	-0.50000
0.25	1.60000	-0.80000	-0.50000
0.30	1.28205	-0.64102	-0.50000
0.40	0.89286	-0.44643	-0.50000
0.50	0.66667	-0.33333	-0.50000
0.60	0.52083	-0.26042	-0.50000
0.70	0.42017	-0.21008	-0.50000
0.80	0.34722	-0.17361	-0.50000
0.90	0.29240	-0.14620	-0.50000
1.00	0.25000	-0.12500	-0.50000
1.25	0.17778	-0.08889	-0.50000
1.50	0.13333	-0.06667	-0.50000
1.75	0.10390	-0.05195	-0.50000
2.00	0.08333	-0.04167	-0.50000
2.25	0.06838	-0.03419	-0.50000
2.50	0.05714	-0.02857	-0.50000
3.00	0.04167	-0.02083	-0.50000
3.50	0.03175	-0.01587	-0.50000
4.00	0.02500	-0.01250	-0.50000
5.00	0.01667	-0.00833	-0.50000

MULTIPLICATOR = Pe_1/L

TABLE 1-2

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN COINCIDING WITH THE CENTROIDAL AXIS.

Y	X_{1N}	X_{2N}	X_{3N}
0.10	-90.90929	-131.01610	-25.47063
0.15	-38.64748	-54.75037	-16.66667
0.20	-20.83336	-29.05702	-11.84211
0.25	-12.80003	-17.60002	-9.00001
0.30	-8.54702	-11.59953	-7.14287
0.40	-4.46430	-5.92003	-4.89131
0.50	-2.66667	-3.46667	-3.60000
0.60	-1.73611	-2.21836	-2.77778
0.70	-1.20048	-1.51095	-2.21675
0.80	-0.86806	-1.07807	-1.81452
0.90	-0.64977	-0.79745	-1.51515
1.00	-0.50000	-0.60714	-1.28571
1.25	-0.28444	-0.33778	-0.90000
1.50	-0.17778	-0.20741	-0.66667
1.75	-0.11874	-0.13655	-0.51429
2.00	-0.08333	-0.09470	-0.40909
2.25	-0.06078	-0.06838	-0.33333
2.50	-0.04571	-0.05099	-0.27692
3.00	-0.02778	-0.03056	-0.20000
3.50	-0.01814	-0.01974	-0.15126
4.00	-0.01250	-0.01349	-0.11842
5.00	-0.00667	-0.00710	-0.07826

MULTIPLICATOR = $P/(L/i)^2$

TABLE 1-3

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_1 AT THE INTERMEDIATE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	-0.22727	0.27273	-0.45455	-0.27273	0.22727
0.15	-0.21739	0.28261	-0.43478	-0.28261	0.21739
0.20	-0.20833	0.29167	-0.41667	-0.29167	0.20833
0.25	-0.20000	0.30000	-0.40000	-0.30000	0.20000
0.30	-0.19231	0.30769	-0.38462	-0.30769	0.19231
0.40	-0.17857	0.32143	-0.35714	-0.32143	0.17857
0.50	-0.16667	0.33333	-0.33333	-0.33333	0.16667
0.60	-0.15625	0.34375	-0.31250	-0.34375	0.15625
0.70	-0.14706	0.35294	-0.29412	-0.35294	0.14706
0.80	-0.13889	0.36111	-0.27778	-0.36111	0.13889
0.90	-0.13158	0.36842	-0.26316	-0.36842	0.13158
1.00	-0.12500	0.37500	-0.25000	-0.37500	0.12500
1.25	-0.11111	0.38889	-0.22222	-0.38889	0.11111
1.50	-0.10000	0.40000	-0.20000	-0.40000	0.10000
1.75	-0.09091	0.40909	-0.18182	-0.40909	0.09091
2.00	-0.08333	0.41667	-0.16667	-0.41667	0.08333
2.25	-0.07692	0.42308	-0.15385	-0.42308	0.07692
2.50	-0.07143	0.42857	-0.14286	-0.42857	0.07143
3.00	-0.06250	0.43750	-0.12500	-0.43750	0.06250
3.50	-0.05556	0.44444	-0.11111	-0.44444	0.05556
4.00	-0.05000	0.45000	-0.10000	-0.45000	0.05000
5.00	-0.04167	0.45833	-0.08333	-0.45833	0.04167

MULTIPLICATOR = Pe_1

TABLE 1-4

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN COINCIDING WITH THE CENTROIDAL AXIS.

Y	M_{bN}	M_{c1N}	M_{c2N}	M_{c3N}	M_{eN}
0.10	22.19254	-4.27809	9.09093	-13.36901	13.10161
0.15	14.00967	-2.65700	5.79712	-8.45412	8.21255
0.20	9.97808	-1.86404	4.16667	-6.03071	5.81140
0.25	7.60001	-1.40000	3.20001	-4.60001	4.40001
0.30	6.04396	-1.09890	2.56411	-3.66301	3.47986
0.40	4.15373	-0.73758	1.78572	-2.52330	2.36801
0.50	3.06667	-0.53333	1.33333	-1.86667	1.73333
0.60	2.37268	-0.40509	1.04167	-1.44676	1.33102
0.70	1.89800	-0.31875	0.84034	-1.15909	1.05766
0.80	1.55690	-0.25762	0.69444	-0.95206	0.86246
0.90	1.30250	-0.21265	0.58480	-0.79745	0.71770
1.00	1.10714	-0.17857	0.50000	-0.67857	0.60714
1.25	0.77778	-0.12222	0.35556	-0.47778	0.42222
1.50	0.57778	-0.08889	0.26667	-0.35556	0.31111
1.75	0.44675	-0.06753	0.20779	-0.27532	0.23896
2.00	0.35606	-0.05303	0.16667	-0.21970	0.18939
2.25	0.29060	-0.04274	0.13675	-0.17949	0.15385
2.50	0.24176	-0.03516	0.11429	-0.14945	0.12747
3.00	0.17500	-0.02500	0.08333	-0.10833	0.09167
3.50	0.13259	-0.01867	0.06349	-0.08217	0.06909
4.00	0.10395	-0.01447	0.05000	-0.06447	0.05395
5.00	0.06884	-0.00942	0.03333	-0.04275	0.03551

MULTIPLICATOR = Pi^2/L

TABLE 2-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_2 AT THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	4.54546	2.13905	0.41177
0.15	2.89855	1.32851	0.37500
0.20	2.08333	0.93202	0.34211
0.25	1.60000	0.70000	0.31250
0.30	1.28205	0.54945	0.28572
0.40	0.89286	0.36879	0.23913
0.50	0.66667	0.26667	0.20000
0.60	0.52083	0.20255	0.16667
0.70	0.42017	0.15937	0.13793
0.80	0.34722	0.12881	0.11290
0.90	0.29240	0.10633	0.09091
1.00	0.25000	0.08929	0.07143
1.25	0.17778	0.06111	0.03125
1.50	0.13333	0.04444	0.00000
1.75	0.10390	0.03377	-0.02500
2.00	0.08333	0.02652	-0.04545
2.25	0.06838	0.02137	-0.06250
2.50	0.05714	0.01758	-0.07692
3.00	0.04167	0.01250	-0.10000
3.50	0.03175	0.00934	-0.11765
4.00	0.02500	0.00724	-0.13158
5.00	0.01667	0.00471	-0.15217

MULTIPLICATOR = Pe_2/L

TABLE 2-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_2 AT THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	-0.66845	0.33155	-0.25668	-0.45455	0.19786	-0.21390
0.15	-0.63406	0.36594	-0.25906	-0.43478	0.17573	-0.19928
0.20	-0.60307	0.39693	-0.26096	-0.41667	0.15570	-0.18640
0.25	-0.57500	0.42500	-0.26250	-0.40000	0.13750	-0.17500
0.30	-0.54945	0.45055	-0.26374	-0.38462	0.12088	-0.16484
0.40	-0.50466	0.49534	-0.26553	-0.35714	0.09162	-0.14752
0.50	-0.46667	0.53333	-0.26667	-0.33333	0.06667	-0.13333
0.60	-0.43403	0.56597	-0.26736	-0.31250	0.04514	-0.12153
0.70	-0.40568	0.59432	-0.26775	-0.29412	0.02637	-0.11156
0.80	-0.38082	0.61918	-0.26792	-0.27778	0.00986	-0.10305
0.90	-0.35885	0.64115	-0.26794	-0.26316	-0.00478	-0.09569
1.00	-0.33929	0.66071	-0.26786	-0.25000	-0.01786	-0.08929
1.25	-0.29861	0.70139	-0.26736	-0.22222	-0.04514	-0.07639
1.50	-0.26667	0.73333	-0.26667	-0.20000	-0.06667	-0.06667
1.75	-0.24091	0.75909	-0.26591	-0.18182	-0.08409	-0.05909
2.00	-0.21970	0.78030	-0.26515	-0.16667	-0.09848	-0.05303
2.25	-0.20192	0.79808	-0.26442	-0.15385	-0.11058	-0.04808
2.50	-0.18681	0.81319	-0.26374	-0.14286	-0.12088	-0.04396
3.00	-0.16250	0.83750	-0.26250	-0.12500	-0.13750	-0.03750
3.50	-0.14379	0.85621	-0.26144	-0.11111	-0.15033	-0.03268
4.00	-0.12895	0.87105	-0.26053	-0.10000	-0.16053	-0.02895
5.00	-0.10688	0.89312	-0.25906	-0.08333	-0.17572	-0.02355

MULTIPLICATOR = Pe_2

TABLE 2-3

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_λ AT A DISTANCE λL FROM THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-4.54545	-1.25669	-0.22941
0.15	-2.89855	-0.77295	-0.20000
0.20	-2.08333	-0.53728	-0.17369
0.25	-1.60000	-0.40000	-0.15000
0.30	-1.28205	-0.31136	-0.12857
0.40	-0.89286	-0.20575	-0.09131
0.50	-0.66667	-0.14667	-0.06000
0.60	-0.52083	-0.10995	-0.03333
0.70	-0.42017	-0.08548	-0.01035
0.80	-0.34722	-0.06832	0.00968
0.90	-0.29240	-0.05582	0.02727
1.00	-0.25000	-0.04643	0.04286
1.25	-0.17778	-0.03111	0.07500
1.50	-0.13333	-0.02222	0.10000
1.75	-0.10390	-0.01662	0.12000
2.00	-0.08333	-0.01288	0.13636
2.25	-0.06838	-0.01026	0.15000
2.50	-0.05714	-0.00835	0.16154
3.00	-0.04167	-0.00583	0.18000
3.50	-0.03175	-0.00430	0.19412
4.00	-0.02500	-0.00329	0.20526
5.00	-0.01667	-0.00210	0.22174

MULTIPLICATOR = Pe_λ/L

($\lambda = 0.20$)

TABLE 2-3.a

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_λ AT A DISTANCE λL FROM THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-4.54545	0.50801	0.13529
0.15	-2.89855	0.33816	0.15000
0.20	-2.08333	0.25219	0.16316
0.25	-1.60000	0.20000	0.17500
0.30	-1.28205	0.16483	0.18571
0.40	-0.89286	0.12034	0.20435
0.50	-0.66667	0.09333	0.22000
0.60	-0.52083	0.07523	0.23333
0.70	-0.42017	0.06230	0.24483
0.80	-0.34722	0.05264	0.25484
0.90	-0.29240	0.04519	0.26364
1.00	-0.25000	0.03929	0.27143
1.25	-0.17778	0.02889	0.28750
1.50	-0.13333	0.02222	0.30000
1.75	-0.10390	0.01766	0.31000
2.00	-0.08333	0.01439	0.31818
2.25	-0.06838	0.01197	0.32500
2.50	-0.05714	0.01011	0.33077
3.00	-0.04167	0.00750	0.34000
3.50	-0.03175	0.00579	0.34706
4.00	-0.02500	0.00461	0.35263
5.00	-0.01667	0.00312	0.36087

MULTIPLICATOR = Pe_λ/L

($\lambda = 0.60$)

TABLE 2-4

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_λ AT A DISTANCE λL FROM THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.58022	0.35080	0.45455	-0.10374	0.12567
0.15	0.55073	0.35072	0.43478	-0.08406	0.11594
0.20	0.52412	0.35044	0.41667	-0.06623	0.10746
0.25	0.50000	0.35000	0.40000	-0.05000	0.10000
0.30	0.47802	0.34945	0.38462	-0.03517	0.09341
0.40	0.43944	0.34814	0.35714	-0.00901	0.08230
0.50	0.40667	0.34667	0.33333	0.01333	0.07333
0.60	0.37847	0.34514	0.31250	0.03264	0.06597
0.70	0.35396	0.34361	0.29412	0.04949	0.05984
0.80	0.33244	0.34211	0.27778	0.06434	0.05466
0.90	0.31340	0.34067	0.26316	0.07751	0.05024
1.00	0.29643	0.33929	0.25000	0.08929	0.04643
1.25	0.26111	0.33611	0.22222	0.11389	0.03889
1.50	0.23333	0.33333	0.20000	0.13333	0.03333
1.75	0.21091	0.33091	0.18182	0.14909	0.02909
2.00	0.19242	0.32879	0.16667	0.16212	0.02576
2.25	0.17692	0.32692	0.15385	0.17308	0.02308
2.50	0.16374	0.32527	0.14286	0.18242	0.02088
3.00	0.14250	0.32250	0.12500	0.19750	0.01750
3.50	0.12614	0.32026	0.11111	0.20915	0.01503
4.00	0.11316	0.31842	0.10000	0.21842	0.01316
5.00	0.09384	0.31558	0.08333	0.23225	0.01051

MULTIPLICATOR = Pe

(λ = 0.20)

TABLE 2-4.a

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_λ AT A DISTANCE λL FROM THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.40374	0.53904	0.45455	0.08449	-0.05080
0.15	0.38406	0.53406	0.43478	0.09927	-0.05072
0.20	0.36623	0.52939	0.41667	0.11272	-0.05044
0.25	0.35000	0.52500	0.40000	0.12500	-0.05000
0.30	0.33517	0.52088	0.38462	0.13626	-0.04945
0.40	0.30901	0.51335	0.35714	0.15621	-0.04814
0.50	0.28667	0.50667	0.33333	0.17333	-0.04667
0.60	0.26736	0.50069	0.31250	0.18819	-0.04514
0.70	0.25051	0.49533	0.29412	0.20122	-0.04361
0.80	0.23566	0.49050	0.27778	0.21272	-0.04211
0.90	0.22249	0.48612	0.26316	0.22297	-0.04067
1.00	0.21071	0.48214	0.25000	0.23214	-0.03929
1.25	0.18611	0.47361	0.22222	0.25139	-0.03611
1.50	0.16667	0.46667	0.20000	0.26667	-0.03333
1.75	0.15091	0.46091	0.18182	0.27909	-0.03091
2.00	0.13788	0.45606	0.16667	0.28939	-0.02879
2.25	0.12692	0.45192	0.15385	0.29808	-0.02692
2.50	0.11758	0.44835	0.14286	0.30549	-0.02527
3.00	0.10250	0.44250	0.12500	0.31750	-0.02250
3.50	0.09085	0.43791	0.11111	0.32680	-0.02026
4.00	0.08158	0.43421	0.10000	0.33421	-0.01842
5.00	0.06775	0.42862	0.08333	0.34529	-0.01558

MULTIPLICATOR = Pe
(λ = 0.60)

TABLE 3-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_3 AT THE MIDDLE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-6.06060	0.08912	0.05882
0.15	-3.86474	0.08051	0.08333
0.20	-2.77778	0.07310	0.10526
0.25	-2.13334	0.06667	0.12500
0.30	-1.70940	0.06105	0.14286
0.40	-1.19048	0.05176	0.17391
0.50	-0.88889	0.04444	0.20000
0.60	-0.69444	0.03858	0.22222
0.70	-0.56022	0.03381	0.24138
0.80	-0.46296	0.02987	0.25806
0.90	-0.38986	0.02658	0.27273
1.00	-0.33333	0.02381	0.28571
1.25	-0.23704	0.01852	0.31250
1.50	-0.17778	0.01481	0.33333
1.75	-0.13853	0.01212	0.35000
2.00	-0.11111	0.01010	0.36364
2.25	-0.09117	0.00855	0.37500
2.50	-0.07619	0.00733	0.38462
3.00	-0.05556	0.00556	0.40000
3.50	-0.04233	0.00436	0.41176
4.00	-0.03333	0.00351	0.42105
5.00	-0.02222	0.00242	0.43478

MULTIPLICATOR = Pe_3/L

TABLE 3-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE FIRST SPAN WITH AN ECCENTRICITY e_3 AT THE MIDDLE, THE EFFLCT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.59715	0.65597	0.60606	0.04991	-0.00891
0.15	0.56763	0.65097	0.57971	0.07126	-0.01208
0.20	0.54094	0.64620	0.55556	0.09064	-0.01462
0.25	0.51667	0.64167	0.53333	0.10833	-0.01667
0.30	0.49451	0.63736	0.51282	0.12454	-0.01831
0.40	0.45549	0.62940	0.47619	0.15321	-0.02070
0.50	0.42222	0.62222	0.44444	0.17778	-0.02222
0.60	0.39352	0.61574	0.41667	0.19907	-0.02315
0.70	0.36849	0.60987	0.39216	0.21771	-0.02366
0.80	0.34648	0.60454	0.37037	0.23417	-0.02389
0.90	0.32695	0.59968	0.35088	0.24880	-0.02392
1.00	0.30952	0.59524	0.33333	0.26190	-0.02381
1.25	0.27315	0.58565	0.29630	0.28935	-0.02315
1.50	0.24444	0.57778	0.26667	0.31111	-0.02222
1.75	0.22121	0.57121	0.24242	0.32879	-0.02121
2.00	0.20202	0.56566	0.22222	0.34343	-0.02020
2.25	0.18590	0.56090	0.20513	0.35577	-0.01923
2.50	0.17216	0.55678	0.19048	0.36630	-0.01832
3.00	0.15000	0.55000	0.16667	0.38333	-0.01667
3.50	0.13290	0.54466	0.14815	0.39651	-0.01525
4.00	0.11930	0.54035	0.13333	0.40702	-0.01404
5.00	0.09903	0.53382	0.11111	0.42271	-0.01208

MULTIPLICATOR = Pe_3

TABLE 4-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN PARALLEL TO THE CENTROIDAL AXIS WITH AN ECCENTRICITY e_4, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	9.09091	-0.13368	-0.08823
0.15	5.79710	-0.12077	-0.12500
0.20	4.16667	-0.10965	-0.15789
0.25	3.20000	-0.10000	-0.18750
0.30	2.56410	-0.09157	-0.21428
0.40	1.78571	-0.07764	-0.26087
0.50	1.33333	-0.06667	-0.30000
0.60	1.04167	-0.05787	-0.33333
0.70	0.84034	-0.05071	-0.36207
0.80	0.69444	-0.04480	-0.38710
0.90	0.58480	-0.03987	-0.40909
1.00	0.50000	-0.03571	-0.42857
1.25	0.35556	-0.02778	-0.46875
1.50	0.26667	-0.02222	-0.50000
1.75	0.20779	-0.01818	-0.52500
2.00	0.16667	-0.01515	-0.54545
2.25	0.13675	-0.01282	-0.56250
2.50	0.11429	-0.01099	-0.57692
3.00	0.08333	-0.00833	-0.60000
3.50	0.06349	-0.00654	-0.61765
4.00	0.05000	-0.00526	-0.63158
5.00	0.03333	-0.00362	-0.65217

MULTIPLICATOR = Pe_4/L

TABLE 4-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE FIRST SPAN PARALLEL TO THE CENTROIDAL AXIS WITH AN ECCENTRICITY e_4, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	-0.89572	0.10428	0.01604	-0.90909	-0.07487	0.01337
0.15	-0.85145	0.14855	0.02355	-0.86957	-0.10688	0.01812
0.20	-0.81140	0.18860	0.03070	-0.83333	-0.13596	0.02193
0.25	-0.77500	0.22500	0.03750	-0.80000	-0.16250	0.02500
0.30	-0.74176	0.25824	0.04396	-0.76923	-0.18681	0.02747
0.40	-0.68323	0.31677	0.05590	-0.71429	-0.22981	0.03106
0.50	-0.63333	0.36667	0.06667	-0.66667	-0.26667	0.03333
0.60	-0.59028	0.40972	0.07639	-0.62500	-0.29861	0.03472
0.70	-0.55274	0.44726	0.08519	-0.58824	-0.32657	0.03550
0.80	-0.51971	0.48029	0.09319	-0.55556	-0.35125	0.03584
0.90	-0.49043	0.50957	0.10048	-0.52632	-0.37321	0.03589
1.00	-0.46429	0.53571	0.10714	-0.50000	-0.39286	0.03571
1.25	-0.40972	0.59028	0.12153	-0.44444	-0.43403	0.03472
1.50	-0.36667	0.63333	0.13333	-0.40000	-0.46667	0.03333
1.75	-0.33182	0.66818	0.14318	-0.36364	-0.49318	0.03182
2.00	-0.30303	0.69697	0.15152	-0.33333	-0.51515	0.03030
2.25	-0.27885	0.72115	0.15865	-0.30769	-0.53365	0.02885
2.50	-0.25824	0.74176	0.16484	-0.28571	-0.54945	0.02747
3.00	-0.22500	0.77500	0.17500	-0.25000	-0.57500	0.02500
3.50	-0.19935	0.80065	0.18301	-0.22222	-0.59477	0.02288
4.00	-0.17895	0.82105	0.18947	-0.20000	-0.61053	0.02105
5.00	-0.14855	0.85145	0.19928	-0.16667	-0.63406	0.01812

MULTIPLICATOR = Pe_4

TABLE 5-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_5 AT THE INTERMEDIATE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	0.00000	0.00000	-1.00000
0.15	0.00000	0.00000	-1.00000
0.20	0.00000	0.00000	-1.00000
0.25	0.00000	0.00000	-1.00000
0.30	0.00000	0.00000	-1.00000
0.40	0.00000	0.00000	-1.00000
0.50	0.00000	0.00000	-1.00000
0.60	0.00000	0.00000	-1.00000
0.70	0.00000	0.00000	-1.00000
0.80	0.00000	0.00000	-1.00000
0.90	0.00000	0.00000	-1.00000
1.00	0.00000	0.00000	-1.00000
1.25	0.00000	0.00000	-1.00000
1.50	0.00000	0.00000	-1.00000
1.75	0.00000	0.00000	-1.00000
2.00	0.00000	0.00000	-1.00000
2.25	0.00000	0.00000	-1.00000
2.50	0.00000	0.00000	-1.00000
3.00	0.00000	0.00000	-1.00000
3.50	0.00000	0.00000	-1.00000
4.00	0.00000	0.00000	-1.00000
5.00	0.00000	0.00000	-1.00000

MULTIPLICATOR = Pe_5/L

TABLE 5-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_5 AT THE INTERMEDIATE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.15	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.20	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.25	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.30	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.40	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.50	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.60	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.70	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.80	-0.00000	0.00000	-0.00000	0.00000	-0.00000
0.90	-0.00000	0.00000	-0.00000	0.00000	-0.00000
1.00	-0.00000	0.00000	-0.00000	0.00000	-0.00000
1.25	-0.00000	0.00000	-0.00000	0.00000	-0.00000
1.50	-0.00000	0.00000	-0.00000	0.00000	-0.00000
1.75	-0.00000	0.00000	-0.00000	0.00000	-0.00000
2.00	-0.00000	0.00000	-0.00000	0.00000	-0.00000
2.25	-0.00000	0.00000	-0.00000	0.00000	-0.00000
2.50	-0.00000	0.00000	-0.00000	0.00000	-0.00000
3.00	-0.00000	0.00000	-0.00000	0.00000	-0.00000
3.50	-0.00000	0.00000	-0.00000	0.00000	-0.00000
4.00	-0.00000	0.00000	-0.00000	0.00000	-0.00000
5.00	-0.00000	0.00000	-0.00000	0.00000	-0.00000

MULTIPLICATOR = Pe_5

TABLE 6-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_6 AT THE TWO EDGE COLUMNS, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	0.00001	8.82354	0.82353
0.15	0.00001	5.55556	0.75000
0.20	0.00000	3.94737	0.68421
0.25	0.00000	3.00000	0.62500
0.30	0.00000	2.38096	0.57143
0.40	0.00000	1.63044	0.47826
0.50	0.00000	1.20000	0.40000
0.60	0.00000	0.92593	0.33333
0.70	-0.00000	0.73892	0.27586
0.80	-0.00000	0.60484	0.22581
0.90	-0.00000	0.50505	0.18182
1.00	0.00000	0.42857	0.14286
1.25	0.00000	0.30000	0.06250
1.50	0.00000	0.22222	0.00000
1.75	0.00000	0.17143	-0.05000
2.00	0.00000	0.13636	-0.09091
2.25	0.00000	0.11111	-0.12500
2.50	0.00000	0.09231	-0.15385
3.00	0.00000	0.06667	-0.20000
3.50	0.00000	0.05042	-0.23529
4.00	0.00000	0.03947	-0.26316
5.00	0.00000	0.02609	-0.30435

MULTIPLICATOR = Pe_6/L

TABLE 6-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_6 AT THE TWO EDGE COLUMNS, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{e2M}	M_{e1M}
0.10	-0.88235	0.11765	-0.05882	-0.00000	-0.05882	0.11765	-0.88235
0.15	-0.83333	0.16667	-0.08333	-0.00000	-0.08333	0.16667	-0.83333
0.20	-0.78947	0.21053	-0.10526	-0.00000	-0.10526	0.21053	-0.78947
0.25	-0.75000	0.25000	-0.12500	-0.00000	-0.12500	0.25000	-0.75000
0.30	-0.71429	0.28571	-0.14286	-0.00000	-0.14286	0.28571	-0.71429
0.40	-0.65217	0.34783	-0.17391	-0.00000	-0.17391	0.34783	-0.65217
0.50	-0.60000	0.40000	-0.20000	-0.00000	-0.20000	0.40000	-0.60000
0.60	-0.55556	0.44444	-0.22222	-0.00000	-0.22222	0.44444	-0.55556
0.70	-0.51724	0.48276	-0.24138	0.00000	-0.24138	0.48276	-0.51724
0.80	-0.48387	0.51613	-0.25806	0.00000	-0.25806	0.51613	-0.48387
0.90	-0.45455	0.54545	-0.27273	0.00000	-0.27273	0.54545	-0.45455
1.00	-0.42857	0.57143	-0.28571	-0.00000	-0.28571	0.57143	-0.42857
1.25	-0.37500	0.62500	-0.31250	-0.00000	-0.31250	0.62500	-0.37500
1.50	-0.33333	0.66667	-0.33333	-0.00000	-0.33333	0.66667	-0.33333
1.75	-0.30000	0.70000	-0.35000	-0.00000	-0.35000	0.70000	-0.30000
2.00	-0.27273	0.72727	-0.36364	-0.00000	-0.36364	0.72727	-0.27273
2.25	-0.25000	0.75000	-0.37500	-0.00000	-0.37500	0.75000	-0.25000
2.50	-0.23077	0.76923	-0.38462	-0.00000	-0.38462	0.76923	-0.23077
3.00	-0.20000	0.80000	-0.40000	-0.00000	-0.40000	0.80000	-0.20000
3.50	-0.17647	0.82353	-0.41176	-0.00000	-0.41176	0.82353	-0.17647
4.00	-0.15789	0.84211	-0.42105	-0.00000	-0.42105	0.84211	-0.15789
5.00	-0.13043	0.86957	-0.43478	-0.00000	-0.43478	0.86957	-0.13043

MULTIPLICATOR = Pe_6

TABLE 7-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN BOTH SPANS WITH AN ECCENTRICITY e_7 AT THE MIDDLE OF EACH ONE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-0.00000	-5.88235	0.11765
0.15	-0.00001	-3.70370	0.16667
0.20	-0.00000	-2.63157	0.21053
0.25	-0.00000	-2.00000	0.25000
0.30	-0.00000	-1.58730	0.28571
0.40	-0.00000	-1.08696	0.34783
0.50	-0.00000	-0.80000	0.40000
0.60	-0.00000	-0.61728	0.44445
0.70	0.00000	-0.49261	0.48276
0.80	-0.00000	-0.40322	0.51613
0.90	-0.00000	-0.33670	0.54546
1.00	-0.00000	-0.28571	0.57143
1.25	-0.00000	-0.20000	0.62500
1.50	-0.00000	-0.14815	0.66667
1.75	-0.00000	-0.11429	0.70000
2.00	-0.00000	-0.09091	0.72727
2.25	0.00000	-0.07407	0.75000
2.50	0.00000	-0.06154	0.76923
3.00	0.00000	-0.04444	0.80000
3.50	-0.00000	-0.03361	0.82353
4.00	0.00000	-0.02632	0.84211
5.00	-0.00000	-0.01739	0.86957

MULTIPLICATOR = Pe_7/L

TABLE 7-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN BOTH SPANS WITH AN ECCENTRICITY e_7 AT THE MIDDLE OF EACH ONE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.58824	0.70588	0.00000	0.70588	0.58824
0.15	0.55556	0.72222	0.00000	0.72222	0.55555
0.20	0.52632	0.73684	0.00000	0.73684	0.52631
0.25	0.50000	0.75000	0.00000	0.75000	0.50000
0.30	0.47619	0.76190	0.00000	0.76190	0.47619
0.40	0.43478	0.78261	0.00000	0.78261	0.43478
0.50	0.40000	0.80000	0.00000	0.80000	0.40000
0.60	0.37037	0.81482	0.00000	0.81482	0.37037
0.70	0.34483	0.82759	-0.00000	0.82759	0.34483
0.80	0.32258	0.83871	0.00000	0.83871	0.32258
0.90	0.30303	0.84849	0.00000	0.84848	0.30303
1.00	0.28571	0.85714	0.00000	0.85714	0.28571
1.25	0.25000	0.87500	0.00000	0.87500	0.25000
1.50	0.22222	0.88889	0.00000	0.88889	0.22222
1.75	0.20000	0.90000	0.00000	0.90000	0.20000
2.00	0.18182	0.90909	0.00000	0.90909	0.18182
2.25	0.16667	0.91667	-0.00000	0.91667	0.16667
2.50	0.15385	0.92308	-0.00000	0.92308	0.15385
3.00	0.13333	0.93333	-0.00000	0.93333	0.13333
3.50	0.11765	0.94118	0.00000	0.94118	0.11765
4.00	0.10526	0.94737	-0.00000	0.94737	0.10526
5.00	0.08696	0.95652	0.00000	0.95652	0.08696

MULTIPLICATOR = Pe_7

TABLE 8-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER PARALLEL TO THE CENTROIDAL AXIS WITH AN ECCENTRICITY e_8, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	0.00000	8.82353	-0.17647
0.15	0.00000	5.55556	-0.25000
0.20	0.00000	3.94737	-0.31579
0.25	0.00000	3.00000	-0.37500
0.30	0.00000	2.38095	-0.42857
0.40	0.00000	1.63043	-0.52174
0.50	0.00000	1.20000	-0.60000
0.60	0.00000	0.92592	-0.66667
0.70	0.00000	0.73892	-0.72414
0.80	0.00000	0.60484	-0.77419
0.90	0.00000	0.50505	-0.81818
1.00	0.00000	0.42857	-0.85714
1.25	0.00000	0.30000	-0.93750
1.50	0.00000	0.22222	-1.00000
1.75	0.00000	0.17143	-1.05000
2.00	0.00000	0.13636	-1.09091
2.25	0.00000	0.11111	-1.12500
2.50	-0.00000	0.09231	-1.15384
3.00	0.00000	0.06667	-1.20000
3.50	0.00000	0.05042	-1.23529
4.00	0.00000	0.03947	-1.26316
5.00	0.00000	0.02609	-1.30435

MULTIPLICATOR = Pe_8/L

TABLE 8-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER PARALLEL TO THE CENTROIDAL AXIS WITH AN ECCENTRICITY e_8, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{e2M}	M_{e1M}
0.10	-0.88235	0.11765	-0.05882	-0.00000	-0.05882	0.11765	-0.88235
0.15	-0.83333	0.16667	-0.08333	-0.00000	-0.08333	0.16667	-0.83333
0.20	-0.78947	0.21053	-0.10526	-0.00000	-0.10526	0.21053	-0.78947
0.25	-0.75000	0.25000	-0.12500	-0.00000	-0.12500	0.25000	-0.75000
0.30	-0.71429	0.28571	-0.14286	-0.00000	-0.14286	0.28571	-0.71429
0.40	-0.65217	0.34783	-0.17391	-0.00000	-0.17391	0.34783	-0.65217
0.50	-0.60000	0.40000	-0.20000	-0.00000	-0.20000	0.40000	-0.60000
0.60	-0.55556	0.44444	-0.22222	-0.00000	-0.22222	0.44445	-0.55555
0.70	-0.51724	0.48276	-0.24138	-0.00000	-0.24138	0.48276	-0.51724
0.80	-0.48387	0.51613	-0.25806	-0.00000	-0.25806	0.51613	-0.48387
0.90	-0.45454	0.54546	-0.27273	-0.00000	-0.27273	0.54546	-0.45454
1.00	-0.42857	0.57143	-0.28571	-0.00000	-0.28571	0.57143	-0.42857
1.25	-0.37500	0.62500	-0.31250	-0.00000	-0.31250	0.62500	-0.37500
1.50	-0.33333	0.66667	-0.33333	-0.00000	-0.33333	0.66667	-0.33333
1.75	-0.30000	0.70000	-0.35000	-0.00000	-0.35000	0.70000	-0.30000
2.00	-0.27273	0.72727	-0.36364	-0.00000	-0.36364	0.72727	-0.27273
2.25	-0.25000	0.75000	-0.37500	-0.00000	-0.37500	0.75000	-0.25000
2.50	-0.23077	0.76923	-0.38461	0.00000	-0.38461	0.76923	-0.23077
3.00	-0.20000	0.80000	-0.40000	-0.00000	-0.40000	0.80000	-0.20000
3.50	-0.17647	0.82353	-0.41176	-0.00000	-0.41176	0.82353	-0.17647
4.00	-0.15789	0.84211	-0.42105	-0.00000	-0.42105	0.84211	-0.15789
5.00	-0.13043	0.86957	-0.43478	-0.00000	-0.43478	0.86957	-0.13043

MULTIPLICATOR = Pe_8

TABLE 9-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_9 AT THE MIDDLE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-0.00000	-1.47058	1.02941
0.15	0.00000	-0.92593	1.04167
0.20	-0.00000	-0.65789	1.05263
0.25	0.00000	-0.50000	1.06250
0.30	-0.00000	-0.39682	1.07143
0.40	-0.00000	-0.27174	1.08696
0.50	-0.00000	-0.20000	1.10000
0.60	-0.00000	-0.15432	1.11111
0.70	-0.00000	-0.12315	1.12069
0.80	-0.00000	-0.10080	1.12903
0.90	-0.00000	-0.08417	1.13636
1.00	-0.00000	-0.07143	1.14286
1.25	-0.00000	-0.05000	1.15625
1.50	-0.00000	-0.03704	1.16667
1.75	0.00000	-0.02857	1.17500
2.00	0.00000	-0.02273	1.18182
2.25	0.00000	-0.01852	1.18750
2.50	0.00000	-0.01538	1.19231
3.00	0.00000	-0.01111	1.20000
3.50	-0.00000	-0.00840	1.20588
4.00	0.00000	-0.00658	1.21053
5.00	-0.00000	-0.00435	1.21739

MULTIPLICATOR = Pe_9/L

TABLE 9-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_9 AT THE MIDDLE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.14706	0.17647	0.00000	0.17647	0.14706
0.15	0.13889	0.18056	-0.00000	0.18056	0.13889
0.20	0.13158	0.18421	0.00000	0.18421	0.13158
0.25	0.12500	0.18750	-0.00000	0.18750	0.12500
0.30	0.11905	0.19048	0.00000	0.19048	0.11905
0.40	0.10870	0.19565	0.00000	0.19565	0.10870
0.50	0.10000	0.20000	0.00000	0.20000	0.10000
0.60	0.09259	0.20370	0.00000	0.20370	0.09259
0.70	0.08621	0.20690	0.00000	0.20690	0.08621
0.80	0.08064	0.20968	0.00000	0.20968	0.08064
0.90	0.07576	0.21212	0.00000	0.21212	0.07576
1.00	0.07143	0.21429	0.00000	0.21428	0.07143
1.25	0.06250	0.21875	0.00000	0.21875	0.06250
1.50	0.05556	0.22222	0.00000	0.22222	0.05556
1.75	0.05000	0.22500	-0.00000	0.22500	0.05000
2.00	0.04545	0.22727	-0.00000	0.22727	0.04545
2.25	0.04167	0.22917	-0.00000	0.22917	0.04167
2.50	0.03846	0.23077	-0.00000	0.23077	0.03846
3.00	0.03333	0.23333	-0.00000	0.23333	0.03333
3.50	0.02941	0.23529	0.00000	0.23529	0.02941
4.00	0.02632	0.23684	-0.00000	0.23684	0.02632
5.00	0.02174	0.23913	0.00000	0.23913	0.02174

MULTIPLICATOR = Pe_9

TABLE 10-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_{10} AT THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	4.54546	2.13904	-0.08823
0.15	2.89855	1.32850	-0.12500
0.20	2.08333	0.93202	-0.15789
0.25	1.60000	0.70000	-0.18750
0.30	1.28205	0.54945	-0.21428
0.40	0.89286	0.36879	-0.26087
0.50	0.66667	0.26667	-0.30000
0.60	0.52083	0.20255	-0.33333
0.70	0.42017	0.15937	-0.36207
0.80	0.34722	0.12881	-0.38710
0.90	0.29240	0.10533	-0.40909
1.00	0.25000	0.08929	-0.42857
1.25	0.17778	0.06111	-0.46875
1.50	0.13333	0.04444	-0.50000
1.75	0.10390	0.03377	-0.52500
2.00	0.08333	0.02652	-0.54545
2.25	0.06838	0.02137	-0.56250
2.50	0.05714	0.01758	-0.57692
3.00	0.04167	0.01250	-0.60000
3.50	0.03175	0.00934	-0.61765
4.00	0.02500	0.00724	-0.63158
5.00	0.01667	0.00471	-0.65217

MULTIPLICATOR = Pe_{10}/L

TABLE 10-2

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE WHOLE GIRDER WITH AN ECCENTRICITY e_{10} AT THE EDGE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	-0.66845	0.33155	-0.25668	-0.45455	0.19786	-0.21390
0.15	-0.63406	0.36594	-0.25906	-0.43478	0.17572	-0.19928
0.20	-0.60307	0.39693	-0.26096	-0.41667	0.15570	-0.18640
0.25	-0.57500	0.42500	-0.26250	-0.40000	0.13750	-0.17500
0.30	-0.54945	0.45055	-0.26374	-0.38462	0.12088	-0.16484
0.40	-0.50466	0.49534	-0.26553	-0.35714	0.09161	-0.14752
0.50	-0.46667	0.53333	-0.26667	-0.33333	0.06667	-0.13333
0.60	-0.43403	0.56597	-0.26736	-0.31250	0.04514	-0.12153
0.70	-0.40568	0.59432	-0.26775	-0.29412	0.02637	-0.11156
0.80	-0.38082	0.61918	-0.26792	-0.27778	0.00986	-0.10305
0.90	-0.35885	0.64115	-0.26794	-0.26316	-0.00478	-0.09569
1.00	-0.33929	0.66071	-0.26786	-0.25000	-0.01786	-0.08929
1.25	-0.29861	0.70139	-0.26736	-0.22222	-0.04514	-0.07639
1.50	-0.26667	0.73333	-0.26667	-0.20000	-0.06667	-0.06667
1.75	-0.24091	0.75909	-0.26591	-0.18182	-0.08409	-0.05909
2.00	-0.21970	0.78030	-0.26515	-0.16667	-0.09848	-0.05303
2.25	-0.20192	0.79808	-0.26442	-0.15385	-0.11058	-0.04808
2.50	-0.18681	0.81319	-0.26374	-0.14286	-0.12088	-0.04396
3.00	-0.16250	0.83750	-0.26250	-0.12500	-0.13750	-0.03750
3.50	-0.14379	0.85621	-0.26144	-0.11111	-0.15033	-0.03268
4.00	-0.12895	0.87105	-0.26053	-0.10000	-0.16053	-0.02895
5.00	-0.10688	0.89312	-0.25906	-0.08333	-0.17572	-0.02355

MULTIPLICATOR = Pe_{10}

TABLE 11-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE EDGE COLUMN WITH AN ECCENTRICITY e_{11} AT THE TOP OF THE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	0.30303	0.43672	0.08824
0.15	0.28986	0.41063	0.12500
0.20	0.27778	0.38743	0.15789
0.25	0.26667	0.36667	0.18750
0.30	0.25641	0.34799	0.21429
0.40	0.23810	0.31573	0.26087
0.50	0.22222	0.28889	0.30000
0.60	0.20833	0.26620	0.33333
0.70	0.19608	0.24679	0.36207
0.80	0.18518	0.22999	0.38710
0.90	0.17544	0.21531	0.40909
1.00	0.16667	0.20238	0.42857
1.25	0.14815	0.17593	0.46875
1.50	0.13333	0.15556	0.50000
1.75	0.12121	0.13939	0.52500
2.00	0.11111	0.12626	0.54545
2.25	0.10256	0.11538	0.56250
2.50	0.09524	0.10623	0.57692
3.00	0.08333	0.09167	0.60000
3.50	0.07407	0.08061	0.61765
4.00	0.06667	0.07193	0.63158
5.00	0.05556	0.05918	0.65217

MULTIPLICATOR = Pe_{11}/L

TABLE 11-2

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE EDGE COLUMN COINCIDING WITH THE CENTROIDAL AXIS OF THE COLUMN.

Y	X_{1N}	X_{2N}	X_{3N}
0.10	-0.00000	-2.64706	-0.54706
0.15	-0.00001	-2.50000	-0.78750
0.20	-0.00000	-2.36842	-1.01053
0.25	-0.00000	-2.25000	-1.21875
0.30	-0.00000	-2.14286	-1.41429
0.40	-0.00000	-1.95652	-1.77391
0.50	-0.00000	-1.80000	-2.10000
0.60	-0.00000	-1.66667	-2.40000
0.70	0.00000	-1.55173	-2.67931
0.80	0.00000	-1.45162	-2.94194
0.90	-0.00000	-1.36364	-3.19091
1.00	-0.00000	-1.28571	-3.42857
1.25	-0.00000	-1.12500	-3.98437
1.50	-0.00000	-1.00000	-4.50000
1.75	-0.00000	-0.90000	-4.98750
2.00	-0.00000	-0.81818	-5.45454
2.25	0.00000	-0.75000	-5.90625
2.50	0.00000	-0.69231	-6.34615
3.00	-0.00000	-0.60000	-7.20000
3.50	-0.00000	-0.52941	-8.02941
4.00	-0.00000	-0.47368	-8.84211
5.00	-0.00000	-0.39130	-10.43478

MULTIPLICATOR = $P/(L/i)^2$

TABLE 11-3

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE EDGE COLUMN WITH AN ECCENTRICITY e_{11} AT THE TOP OF THE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.92602	-0.07398	0.01426	-0.03030	0.04456	-0.04367
0.15	0.89493	-0.10507	0.01993	-0.04348	0.06341	-0.06159
0.20	0.86696	-0.13304	0.02485	-0.05556	0.08041	-0.07749
0.25	0.84167	-0.15833	0.02917	-0.06667	0.09583	-0.09167
0.30	0.81868	-0.18132	0.03297	-0.07692	0.10989	-0.10440
0.40	0.77847	-0.22153	0.03934	-0.09524	0.13458	-0.12629
0.50	0.74444	-0.25556	0.04444	-0.11111	0.15556	-0.14444
0.60	0.71528	-0.28472	0.04861	-0.12500	0.17361	-0.15972
0.70	0.68999	-0.31001	0.05206	-0.13725	0.18932	-0.17275
0.80	0.66786	-0.33214	0.05496	-0.14815	0.20311	-0.18399
0.90	0.64833	-0.35167	0.05742	-0.15789	0.21531	-0.19378
1.00	0.63095	-0.36905	0.05952	-0.16667	0.22619	-0.20238
1.25	0.59491	-0.40509	0.06366	-0.18519	0.24884	-0.21991
1.50	0.56667	-0.43333	0.06667	-0.20000	0.26667	-0.23333
1.75	0.54394	-0.45606	0.06894	-0.21212	0.28106	-0.24394
2.00	0.52525	-0.47475	0.07071	-0.22222	0.29293	-0.25252
2.25	0.50962	-0.49038	0.07212	-0.23077	0.30288	-0.25962
2.50	0.49634	-0.50366	0.07326	-0.23810	0.31136	-0.26557
3.00	0.47500	-0.52500	0.07500	-0.25000	0.32500	-0.27500
3.50	0.45861	-0.54139	0.07625	-0.25926	0.33551	-0.28213
4.00	0.44561	-0.55439	0.07719	-0.26667	0.34386	-0.28772
5.00	0.42633	-0.57367	0.07850	-0.27778	0.35628	-0.29589

MULTIPLICATOR = Pe_{11}

TABLE 11-4

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE EDGE COLUMN COINCIDING WITH THE CENTROIDAL AXIS OF THE COLUMN.

Y	M_{bN}	M_{c1N}	M_{c2N}	M_{c3N}	M_{eN}
0.10	0.26471	-0.28235	0.00000	-0.28235	0.26471
0.15	0.37500	-0.41250	0.00000	-0.41250	0.37500
0.20	0.47368	-0.53684	0.00000	-0.53684	0.47368
0.25	0.56250	-0.65625	0.00000	-0.65625	0.56250
0.30	0.64286	-0.77143	0.00000	-0.77143	0.64286
0.40	0.78261	-0.99130	0.00000	-0.99131	0.78261
0.50	0.90000	-1.20000	0.00000	-1.20000	0.90000
0.60	1.00000	-1.40000	0.00000	-1.40000	1.00000
0.70	1.08621	-1.59311	-0.00000	-1.59310	1.08621
0.80	1.16129	-1.78065	-0.00000	-1.78065	1.16129
0.90	1.22727	-1.96364	0.00000	-1.96364	1.22727
1.00	1.28571	-2.14286	0.00000	-2.14286	1.28571
1.25	1.40625	-2.57813	0.00000	-2.57813	1.40625
1.50	1.50000	-3.00000	0.00000	-3.00000	1.50000
1.75	1.57500	-3.41250	0.00000	-3.41250	1.57500
2.00	1.63636	-3.81818	0.00000	-3.81818	1.63636
2.25	1.68750	-4.21875	-0.00000	-4.21875	1.68750
2.50	1.73077	-4.61533	-0.00000	-4.61538	1.73077
3.00	1.80000	-5.40000	0.00000	-5.40000	1.80000
3.50	1.85294	-6.17647	0.00000	-6.17647	1.85294
4.00	1.89474	-6.94737	0.00000	-6.94737	1.89474
5.00	1.95652	-8.47826	0.00000	-8.47826	1.95652

MULTIPLICATOR = Pi^2/L

TABLE 11-5

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE EDGE COLUMN WITH AN ECCENTRICITY e AT THE MIDDLE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-0.30303	-0.43672	-0.08824
0.15	-0.28986	-0.41063	-0.12500
0.20	-0.27778	-0.38743	-0.15789
0.25	-0.26667	-0.36667	-0.18750
0.30	-0.25641	-0.34799	-0.21429
0.40	-0.23810	-0.31573	-0.26087
0.50	-0.22222	-0.28889	-0.30000
0.60	-0.20833	-0.26620	-0.33333
0.70	-0.19608	-0.24679	-0.36207
0.80	-0.18518	-0.22999	-0.38710
0.90	-0.17544	-0.21531	-0.40909
1.00	-0.16667	-0.20238	-0.42857
1.25	-0.14815	-0.17593	-0.46875
1.50	-0.13333	-0.15556	-0.50000
1.75	-0.12121	-0.13939	-0.52500
2.00	-0.11111	-0.12626	-0.54545
2.25	-0.10256	-0.11538	-0.56250
2.50	-0.09524	-0.10623	-0.57692
3.00	-0.08333	-0.09167	-0.60000
3.50	-0.07407	-0.08061	-0.61765
4.00	-0.06667	-0.07193	-0.63158
5.00	-0.05556	-0.05918	-0.65217

MULTIPLICATOR = Pe/L

TABLE 11-6

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A PARABOLIC CABLE IN THE EDGE COLUMN WITH AN ECCENTRICITY e AT THE MIDDLE, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.07398	-0.01426	0.03030	-0.04456	0.04367
0.15	0.10507	-0.01993	0.04348	-0.06341	0.06159
0.20	0.13304	-0.02485	0.05556	-0.08041	0.07749
0.25	0.15833	-0.02917	0.06667	-0.09583	0.09167
0.30	0.18132	-0.03297	0.07692	-0.10989	0.10440
0.40	0.22153	-0.03934	0.09524	-0.13458	0.12629
0.50	0.25556	-0.04444	0.11111	-0.15556	0.14444
0.60	0.28472	-0.04861	0.12500	-0.17361	0.15972
0.70	0.31001	-0.05206	0.13725	-0.18932	0.17275
0.80	0.33214	-0.05496	0.14815	-0.20311	0.18399
0.90	0.35167	-0.05742	0.15789	-0.21531	0.19378
1.00	0.36905	-0.05952	0.16667	-0.22619	0.20238
1.25	0.40509	-0.06366	0.18519	-0.24884	0.21991
1.50	0.43333	-0.06667	0.20000	-0.26667	0.23333
1.75	0.45606	-0.06894	0.21212	-0.28106	0.24394
2.00	0.47475	-0.07071	0.22222	-0.29293	0.25252
2.25	0.49038	-0.07212	0.23077	-0.30288	0.25962
2.50	0.50366	-0.07326	0.23810	-0.31136	0.26557
3.00	0.52500	-0.07500	0.25000	-0.32500	0.27500
3.50	0.54139	-0.07625	0.25926	-0.33551	0.28213
4.00	0.55439	-0.07719	0.26667	-0.34386	0.28772
5.00	0.57367	-0.07850	0.27778	-0.35628	0.29589

MULTIPLICATOR = Pe

TABLE 11-7

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE WITH AN ECCENTRICITY AT THE TOP OF THE COLUMN AND ANCHORED AT A DISTANCE λh FROM THE SUPPORT, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-0.21818	-0.31444	-0.06353
0.15	-0.20870	-0.29565	-0.09000
0.20	-0.20000	-0.27895	-0.11368
0.25	-0.19200	-0.26400	-0.13500
0.30	-0.18462	-0.25055	-0.15429
0.40	-0.17143	-0.22733	-0.18783
0.50	-0.16000	-0.20800	-0.21600
0.60	-0.15000	-0.19167	-0.24000
0.70	-0.14118	-0.17769	-0.26069
0.80	-0.13333	-0.16559	-0.27871
0.90	-0.12632	-0.15502	-0.29455
1.00	-0.12000	-0.14571	-0.30857
1.25	-0.10667	-0.12667	-0.33750
1.50	-0.09600	-0.11200	-0.36000
1.75	-0.08727	-0.10036	-0.37800
2.00	-0.08000	-0.09091	-0.39273
2.25	-0.07385	-0.08308	-0.40500
2.50	-0.06857	-0.07648	-0.41538
3.00	-0.06000	-0.06600	-0.43200
3.50	-0.05333	-0.05804	-0.44471
4.00	-0.04800	-0.05179	-0.45474
5.00	-0.04000	-0.04261	-0.46957

MULTIPLICATOR = Pe/L

(λ= 0.4)

TABLE 11-8

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE WITH AN ECCENTRICITY AT THE TOP OF THE COLUMN AND ANCHORED AT A DISTANCE λh FROM THE SUPPORT, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{b1M}	M_{b2M}	M_{c1M}	M_{c2M}	M_{c3M}	M_{cM}
0.10	-0.94674	0.05326	-0.01027	0.02182	-0.03209	0.03144
0.15	-0.92435	0.07565	-0.01435	0.03130	-0.04565	0.04435
0.20	-0.90421	0.09579	-0.01789	0.04000	-0.05789	0.05579
0.25	-0.88600	0.11400	-0.02100	0.04800	-0.06900	0.06600
0.30	-0.86945	0.13055	-0.02374	0.05538	-0.07912	0.07516
0.40	-0.84050	0.15950	-0.02832	0.06857	-0.09689	0.09093
0.50	-0.81600	0.18400	-0.03200	0.08000	-0.11200	0.10400
0.60	-0.79500	0.20500	-0.03500	0.09000	-0.12500	0.11500
0.70	-0.77680	0.22320	-0.03749	0.09882	-0.13631	0.12438
0.80	-0.76086	0.23914	-0.03957	0.10667	-0.14624	0.13247
0.90	-0.74679	0.25321	-0.04134	0.11368	-0.15502	0.13952
1.00	-0.73429	0.26571	-0.04286	0.12000	-0.16286	0.14571
1.25	-0.70833	0.29167	-0.04583	0.13333	-0.17917	0.15833
1.50	-0.68800	0.31200	-0.04800	0.14400	-0.19200	0.16800
1.75	-0.67164	0.32836	-0.04964	0.15273	-0.20236	0.17564
2.00	-0.65818	0.34182	-0.05091	0.16000	-0.21091	0.18182
2.25	-0.64692	0.35308	-0.05192	0.16615	-0.21808	0.18692
2.50	-0.63736	0.36264	-0.05275	0.17143	-0.22418	0.19121
3.00	-0.62200	0.37800	-0.05400	0.18000	-0.23400	0.19800
3.50	-0.61020	0.38980	-0.05490	0.18667	-0.24157	0.20314
4.00	-0.60084	0.39916	-0.05558	0.19200	-0.24758	0.20716
5.00	-0.58696	0.41304	-0.05652	0.20000	-0.25652	0.21304

MULTIPLICATOR = P.e

(λ= 0.4)

TABLE 11-9

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE EDGE COLUMN AND ANCHORED AT A DISTANCE FROM THE SUPPORT.

Y	X_{1N}	X_{2N}	X_{3N}
0.10	-0.00000	-1.58824	-0.32824
0.15	-0.00001	-1.50000	-0.47250
0.20	-0.00000	-1.42105	-0.60632
0.25	-0.00000	-1.35000	-0.73125
0.30	0.00000	-1.28572	-0.84857
0.40	-0.00000	-1.17391	-1.06435
0.50	-0.00000	-1.08000	-1.26000
0.60	-0.00000	-1.00000	-1.44000
0.70	0.00000	-0.93104	-1.60759
0.80	0.00000	-0.87097	-1.76516
0.90	0.00000	-0.81818	-1.91455
1.00	-0.00000	-0.77143	-2.05714
1.25	-0.00000	-0.67500	-2.39062
1.50	-0.00000	-0.60000	-2.70000
1.75	-0.00000	-0.54000	-2.99250
2.00	-0.00000	-0.49091	-3.27272
2.25	0.00000	-0.45000	-3.54375
2.50	0.00000	-0.41538	-3.80769
3.00	-0.00000	-0.36000	-4.32000
3.50	-0.00000	-0.31765	-4.81765
4.00	-0.00000	-0.28421	-5.30526
5.00	-0.00000	-0.23478	-6.26087

MULTIPLICATOR = $P/(L/i)^2$

TABLE 11-10

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE EDGE COLUMN AND ANCHORED AT A DISTANCE λh FROM THE SUPPORT.

Y	M_{bN}	M_{c1N}	M_{c2N}	M_{c3N}	M_{eN}
0.10	0.15882	-0.16941	0.00000	-0.16941	0.15882
0.15	0.22500	-0.24750	0.00000	-0.24750	0.22500
0.20	0.28421	-0.32210	0.00000	-0.32211	0.28421
0.25	0.33750	-0.39375	0.00000	-0.39375	0.33750
0.30	0.38571	-0.46286	-0.00000	-0.46286	0.38571
0.40	0.46956	-0.59478	0.00000	-0.59478	0.46956
0.50	0.54000	-0.72000	0.00000	-0.72000	0.54000
0.60	0.60000	-0.84000	0.00000	-0.84000	0.60000
0.70	0.65172	-0.95586	-0.00000	-0.95586	0.65172
0.80	0.69677	-1.06839	-0.00000	-1.06839	0.69678
0.90	0.73636	-1.17818	-0.00000	-1.17818	0.73636
1.00	0.77143	-1.28571	0.00000	-1.28571	0.77143
1.25	0.84375	-1.54687	0.00000	-1.54687	0.84375
1.50	0.90000	-1.80000	0.00000	-1.80000	0.90000
1.75	0.94500	-2.04750	0.00000	-2.04750	0.94500
2.00	0.98182	-2.29091	0.00000	-2.29091	0.98182
2.25	1.01250	-2.53125	-0.00000	-2.53125	1.01250
2.50	1.03846	-2.76923	-0.00000	-2.76923	1.03846
3.00	1.08000	-3.24000	0.00000	-3.24000	1.08000
3.50	1.11176	-3.70588	0.00000	-3.70588	1.11176
4.00	1.13684	-4.16842	0.00000	-4.16842	1.13684
5.00	1.17391	-5.08696	0.00000	-5.08696	1.17391

MULTIPLICATOR = Pi^2/L

TABLE 12-1

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE INTERMEDIATE COLUMN WITH AN ECCENTRICITY e_{12} AT THE TOP OF THE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	X_{1M}	X_{2M}	X_{3M}
0.10	-0.60606	0.30303	-0.00000
0.15	-0.57971	0.28985	-0.00000
0.20	-0.55556	0.27778	0.00000
0.25	-0.53333	0.26667	0.00000
0.30	-0.51282	0.25641	-0.00000
0.40	-0.47619	0.23810	-0.00000
0.50	-0.44444	0.22222	-0.00000
0.60	-0.41667	0.20833	-0.00000
0.70	-0.39216	0.19608	0.00000
0.80	-0.37037	0.18519	0.00000
0.90	-0.35088	0.17544	0.00000
1.00	-0.33333	0.16667	-0.00000
1.25	-0.29630	0.14815	-0.00000
1.50	-0.26667	0.13333	-0.00000
1.75	-0.24242	0.12121	-0.00000
2.00	-0.22222	0.11111	-0.00000
2.25	-0.20513	0.10256	0.00000
2.50	-0.19048	0.09524	0.00000
3.00	-0.16667	0.08333	-0.00000
3.50	-0.14815	0.07407	-0.00000
4.00	-0.13333	0.06667	0.00000
5.00	-0.11111	0.05556	-0.00000

MULTIPLICATOR = Pe_{12}/L

TABLE 12-2

PARASITIC REACTIONS CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE INTERMEDIATE COLUMN WITH A CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE COLUMN.

Y	X_{1N}	X_{2N}	X_{3N}
0.10	0.00002	5.29412	1.09412
0.15	-0.00000	4.99999	1.57500
0.20	-0.00001	4.73684	2.02105
0.25	0.00000	4.50001	2.43750
0.30	0.00000	4.28572	2.82858
0.40	0.00000	3.91304	3.54783
0.50	0.00001	3.60000	4.20000
0.60	0.00000	3.33333	4.80000
0.70	-0.00000	3.10345	5.35862
0.80	-0.00000	2.90323	5.88387
0.90	0.00000	2.72727	6.38182
1.00	0.00000	2.57143	6.85714
1.25	0.00000	2.25000	7.96875
1.50	0.00000	2.00000	9.00000
1.75	0.00000	1.80000	9.97499
2.00	0.00000	1.63636	10.90909
2.25	-0.00000	1.50000	11.81250
2.50	0.00000	1.38461	12.69231
3.00	0.00000	1.20000	14.40001
3.50	0.00000	1.05882	16.05882
4.00	0.00000	0.94737	17.68420
5.00	0.00000	0.78261	20.86957

MULTIPLICATOR = $P/(L/i)^2$

TABLE 12-3

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE INTERMEDIATE COLUMN WITH AN ECCENTRICITY e_{12} AT THE TOP OF THE COLUMN, THE EFFECT OF AXIAL DEFORMATIONS BEING NEGLECTED.

Y	M_{bM}	M_{c1M}	M_{c2M}	M_{c3M}	M_{eM}
0.10	0.03030	0.03030	-0.93939	-0.03030	-0.03030
0.15	0.04348	0.04348	-0.91304	-0.04348	-0.04348
0.20	0.05556	0.05556	-0.88889	-0.05556	-0.05556
0.25	0.06667	0.06667	-0.86667	-0.06667	-0.06667
0.30	0.07692	0.07692	-0.84615	-0.07692	-0.07692
0.40	0.09524	0.09524	-0.80952	-0.09524	-0.09524
0.50	0.11111	0.11111	-0.77778	-0.11111	-0.11111
0.60	0.12500	0.12500	-0.75000	-0.12500	-0.12500
0.70	0.13725	0.13726	-0.72549	-0.13725	-0.13726
0.80	0.14815	0.14815	-0.70370	-0.14815	-0.14815
0.90	0.15789	0.15789	-0.68421	-0.15789	-0.15789
1.00	0.16667	0.16667	-0.66667	-0.16667	-0.16667
1.25	0.18519	0.18519	-0.62963	-0.18519	-0.18518
1.50	0.20000	0.20000	-0.60000	-0.20000	-0.20000
1.75	0.21212	0.21212	-0.57576	-0.21212	-0.21212
2.00	0.22222	0.22222	-0.55556	-0.22222	-0.22222
2.25	0.23077	0.23077	-0.53846	-0.23077	-0.23077
2.50	0.23810	0.23810	-0.52381	-0.23809	-0.23810
3.00	0.25000	0.25000	-0.50000	-0.25000	-0.25000
3.50	0.25926	0.25926	-0.48148	-0.25926	-0.25926
4.00	0.26667	0.26667	-0.46667	-0.26667	-0.26667
5.00	0.27778	0.27778	-0.44444	-0.27778	-0.27778

MULTIPLICATOR = Pe_{12}

TABLE 12-4

BENDING MOMENT CAUSED BY THE PRESTRESSING OF A LINEAR CABLE IN THE INTERMEDIATE COLUMN WITH A CABLE COINCIDING WITH THE CENTROIDAL AXIS OF THE COLUMN.

Y	M_{bN}	M_{c1N}	M_{c2N}	M_{c3N}	M_{eN}
0.10	-0.52941	0.56471	-0.00000	0.56471	-0.52941
0.15	-0.75000	0.82500	0.00000	0.82500	-0.75000
0.20	-0.94737	1.07369	0.00000	1.07368	-0.94737
0.25	-1.12500	1.31250	-0.00000	1.31250	-1.12500
0.30	-1.28572	1.54286	-0.00000	1.54286	-1.28572
0.40	-1.56522	1.98261	-0.00000	1.98261	-1.56522
0.50	-1.80000	2.40000	-0.00000	2.40000	-1.80000
0.60	-2.00000	2.80000	-0.00000	2.80000	-2.00000
0.70	-2.17241	3.18621	0.00000	3.18621	-2.17242
0.80	-2.32258	3.56129	0.00000	3.56129	-2.32258
0.90	-2.45455	3.92727	-0.00000	3.92727	-2.45455
1.00	-2.57143	4.28571	-0.00000	4.28572	-2.57143
1.25	-2.81250	5.15625	-0.00000	5.15625	-2.81250
1.50	-3.00000	6.00000	-0.00000	6.00000	-3.00000
1.75	-3.15000	6.82500	-0.00000	6.82500	-3.14999
2.00	-3.27272	7.63636	-0.00000	7.63636	-3.27272
2.25	-3.37500	8.43750	0.00000	8.43750	-3.37500
2.50	-3.46153	9.23077	-0.00000	9.23077	-3.46153
3.00	-3.60000	10.80000	-0.00000	10.80000	-3.60000
3.50	-3.70588	12.35294	-0.00000	12.35294	-3.70588
4.00	-3.78947	13.89473	-0.00000	13.89473	-3.78947
5.00	-3.91304	16.95651	-0.00000	16.95651	-3.91304

MULTIPLICATOR = Pl^2/L

TABLE 13

BENDING MOMENT DUE TO DISTRIBUTED LOAD OVER THE FIRST SPAN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.59715	-0.65597	-0.60606	-0.04991	0.00891
0.15	-0.56763	-0.65097	-0.57971	-0.07125	0.01208
0.20	-0.54094	-0.64620	-0.55556	-0.09064	0.01462
0.25	-0.51667	-0.64167	-0.53333	-0.10833	0.01667
0.30	-0.49451	-0.63736	-0.51282	-0.12454	0.01831
0.40	-0.45549	-0.62940	-0.47619	-0.15321	0.02070
0.50	-0.42222	-0.62222	-0.44444	-0.17778	0.02222
0.60	-0.39352	-0.61574	-0.41667	-0.19907	0.02315
0.70	-0.36849	-0.60987	-0.39216	-0.21771	0.02366
0.80	-0.34648	-0.60454	-0.37037	-0.23417	0.02389
0.90	-0.32695	-0.59968	-0.35088	-0.24880	0.02392
1.00	-0.30952	-0.59524	-0.33333	-0.26190	0.02381
1.25	-0.27315	-0.58565	-0.29630	-0.28935	0.02315
1.50	-0.24444	-0.57778	-0.26667	-0.31111	0.02222
1.75	-0.22121	-0.57121	-0.24242	-0.32879	0.02121
2.00	-0.20202	-0.56566	-0.22222	-0.34343	0.02020
2.25	-0.18590	-0.56090	-0.20513	-0.35577	0.01923
2.50	-0.17216	-0.55678	-0.19048	-0.36630	0.01832
3.00	-0.15000	-0.55000	-0.16667	-0.38333	0.01667
3.50	-0.13290	-0.54466	-0.14815	-0.39651	0.01525
4.00	-0.11930	-0.54035	-0.13333	-0.40702	0.01404
5.00	-0.09903	-0.53382	-0.11111	-0.42271	0.01208

MULTIPLICATOR = $wL^2/8$

TABLE 14

BENDING MOMENT DUE TO DISTRIBUTED LOAD OVER THE WHOLE GIRDER.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.58824	-0.70588	0.00000	-0.70588	-0.58824
0.15	-0.55556	-0.72222	0.00000	-0.72222	-0.55556
0.20	-0.52632	-0.73684	0.00000	-0.73684	-0.52632
0.25	-0.50000	-0.75000	0.00000	-0.75000	-0.50000
0.30	-0.47619	-0.76190	0.00000	-0.76190	-0.47619
0.40	-0.43478	-0.78261	0.00000	-0.78261	-0.43478
0.50	-0.40000	-0.80000	0.00000	-0.80000	-0.40000
0.60	-0.37037	-0.81481	0.00000	-0.81481	-0.37037
0.70	-0.34483	-0.82759	0.00000	-0.82759	-0.34483
0.80	-0.32258	-0.83871	0.00000	-0.83871	-0.32258
0.90	-0.30303	-0.84848	0.00000	-0.84848	-0.30303
1.00	-0.28571	-0.85714	0.00000	-0.85714	-0.28571
1.25	-0.25000	-0.87500	0.00000	-0.87500	-0.25000
1.50	-0.22222	-0.88889	0.00000	-0.88889	-0.22222
1.75	-0.20000	-0.90000	0.00000	-0.90000	-0.20000
2.00	-0.18182	-0.90909	0.00000	-0.90909	-0.18182
2.25	-0.16667	-0.91667	0.00000	-0.91667	-0.16667
2.50	-0.15385	-0.92308	0.00000	-0.92308	-0.15385
3.00	-0.13333	-0.93333	0.00000	-0.93333	-0.13333
3.50	-0.11765	-0.94118	0.00000	-0.94118	-0.11765
4.00	-0.10526	-0.94737	0.00000	-0.94737	-0.10526
5.00	-0.08696	-0.95652	0.00000	-0.95652	-0.08696

MULTIPLICATOR = $wL^2/8$

TABLE 15

BENDING MOMENT DUE TO LATERAL DISTRIBUTED LOAD ON THE EDGE COLUMN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	0.00956	-0.00955	-0.01970	0.01014	-0.01074
0.15	0.02111	-0.02107	-0.04402	0.02295	-0.02486
0.20	0.03690	-0.03673	-0.07778	0.04099	-0.04532
0.25	0.05677	-0.05651	-0.12083	0.06432	-0.07240
0.30	0.08060	-0.08011	-0.17308	0.09297	-0.10632
0.40	0.13979	-0.13847	-0.30476	0.16629	-0.19545
0.50	0.21389	-0.21111	-0.47222	0.26111	-0.31389
0.60	0.30250	-0.29750	-0.67500	0.37750	-0.46250
0.70	0.40535	-0.39723	-0.91274	0.51551	-0.64190
0.80	0.52225	-0.51001	-1.18518	0.67517	-0.85257
0.90	0.65304	-0.63560	-1.49210	0.85651	-1.09486
1.00	0.79762	-0.77381	-1.83333	1.05952	-1.36905
1.25	1.21890	-1.17369	-2.83565	1.66196	-2.19545
1.50	1.72500	-1.65000	-4.05000	2.40000	-3.22500
1.75	2.31545	-2.20176	-5.47538	3.27362	-4.45918
2.00	2.98991	-2.82829	-7.11111	4.28282	-5.89898
2.25	3.74820	-3.52914	-8.95672	5.42758	-7.54508
2.50	4.59021	-4.30405	-11.01191	6.70786	-9.39788
3.00	6.52499	-6.07498	-15.75000	9.67501	-13.72502
3.50	8.79387	-8.13997	-21.32407	13.18410	-18.88206
4.00	11.39653	-10.49828	-27.73332	17.23505	-24.87015
5.00	17.60269	-16.09297	-43.05554	26.96257	-39.34177

MULTIPLICATOR = $wL^2/8$

TABLE 16.

BENDING MOMENT DUE TO LATERAL CONCENTRATED LOAD ON THE EDGE COLUMN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	0.03624	-0.03783	-0.07961	0.04178	-0.04415
0.15	0.05202	-0.05538	-0.11917	0.06378	-0.06882
0.20	0.06656	-0.07221	-0.15858	0.08635	-0.09486
0.25	0.08007	-0.08843	-0.19787	0.10943	-0.12207
0.30	0.09268	-0.10412	-0.23705	0.13292	-0.15028
0.40	0.11569	-0.13419	-0.31512	0.18094	-0.20919
0.50	0.13636	-0.16284	-0.39289	0.23004	-0.27076
0.60	0.15520	-0.19040	-0.47040	0.28000	-0.33440
0.70	0.17260	-0.21706	-0.54770	0.33062	-0.39969
0.80	0.18885	-0.24305	-0.62483	0.38178	-0.46632
0.90	0.20415	-0.26843	-0.70181	0.43338	-0.53404
1.00	0.21867	-0.29333	-0.77867	0.48533	-0.60267
1.25	0.25232	-0.35394	-0.97037	0.61643	-0.77731
1.50	0.28320	-0.41280	-1.16160	0.74880	-0.95520
1.75	0.31216	-0.47044	-1.35248	0.88204	-1.13536
2.00	0.33972	-0.52719	-1.54311	1.01592	-1.31717
2.25	0.36623	-0.58327	-1.73354	1.15027	-1.50023
2.50	0.39195	-0.63883	-1.92381	1.28498	-1.68425
3.00	0.44160	-0.74880	-2.30400	1.55520	-2.05440
3.50	0.48961	-0.85769	-2.68385	1.82616	-2.42654
4.00	0.53648	-0.96584	-3.06347	2.09763	-2.80006
5.00	0.62802	-1.18068	-3.82222	2.64155	-3.54976

MULTIPLICATOR = WL/4
(λ = 0.4)

TABLE 16.a

BENDING MOMENT DUE TO LATERAL CONCENTRATED LOAD ON THE EDGE COLUMN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	0.10303	-0.09697	-0.19394	0.09697	-0.10303
0.15	0.15652	-0.14348	-0.28696	0.14348	-0.15652
0.20	0.21111	-0.18889	-0.37778	0.18889	-0.21111
0.25	0.26667	-0.23333	-0.46667	0.23333	-0.26667
0.30	0.32308	-0.27692	-0.55385	0.27692	-0.32308
0.40	0.43810	-0.36190	-0.72381	0.36191	-0.43810
0.50	0.55556	-0.44444	-0.88889	0.44444	-0.55556
0.60	0.67500	-0.52500	-1.05000	0.52500	-0.67500
0.70	0.79608	-0.60392	-1.20784	0.60392	-0.79608
0.80	0.91852	-0.68148	-1.36296	0.68148	-0.91852
0.90	1.04210	-0.75789	-1.51579	0.75790	-1.04211
1.00	1.16667	-0.83333	-1.66667	0.83333	-1.16667
1.25	1.48148	-1.01852	-2.03704	1.01852	-1.48148
1.50	1.80000	-1.20000	-2.40000	1.20000	-1.80000
1.75	2.12121	-1.37879	-2.75758	1.37879	-2.12121
2.00	2.44445	-1.55556	-3.11111	1.55555	-2.44444
2.25	2.76923	-1.73077	-3.46153	1.73077	-2.76924
2.50	3.09524	-1.90476	-3.80952	1.90476	-3.09524
3.00	3.74999	-2.24999	-4.50000	2.25001	-3.75001
3.50	4.40740	-2.59259	-5.18519	2.59260	-4.40741
4.00	5.06667	-2.93333	-5.86667	2.93334	-5.06667
5.00	6.38889	-3.61111	-7.22222	3.61111	-6.38889

MULTIPLICATOR = WL/4

($\lambda = 1.00$)

TABLE 17

BENDING MOMENT DUE TO CONCENTRATED LOAD OVER THE FIRST SPAN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.37134	-0.22451	-0.29091	0.06640	-0.08043
0.15	-0.35246	-0.22446	-0.27825	0.05380	-0.07420
0.20	-0.33544	-0.22428	-0.26667	0.04239	-0.06877
0.25	-0.32000	-0.22400	-0.25600	0.03200	-0.06400
0.30	-0.30593	-0.22365	-0.24615	0.02251	-0.05978
0.40	-0.28124	-0.22281	-0.22857	0.00575	-0.05267
0.50	-0.26027	-0.22187	-0.21333	-0.00853	-0.04693
0.60	-0.24222	-0.22089	-0.20000	-0.02089	-0.04222
0.70	-0.22653	-0.21991	-0.18824	-0.03168	-0.03830
0.80	-0.21276	-0.21895	-0.17778	-0.04118	-0.03498
0.90	-0.20057	-0.21803	-0.16842	-0.04951	-0.03215
1.00	-0.18971	-0.21714	-0.16000	-0.05714	-0.02971
1.25	-0.16711	-0.21511	-0.14222	-0.07289	-0.02489
1.50	-0.14933	-0.21333	-0.12800	-0.08533	-0.02133
1.75	-0.13498	-0.21178	-0.11636	-0.09542	-0.01862
2.00	-0.12315	-0.21042	-0.10667	-0.10376	-0.01648
2.25	-0.11323	-0.20923	-0.09846	-0.11077	-0.01477
2.50	-0.10479	-0.20818	-0.09143	-0.11675	-0.01336
3.00	-0.09120	-0.20640	-0.08000	-0.12640	-0.01120
3.50	-0.08073	-0.20497	-0.07111	-0.13386	-0.00962
4.00	-0.07242	-0.20379	-0.06400	-0.13979	-0.00842
5.00	-0.06006	-0.20197	-0.05333	-0.14864	-0.00672

MULTIPLICATOR = WL/4
(λ = 0.20)

TABLE 17.a

BENDING MOMENT DUE TO CONCENTRATED LOAD OVER THE FIRST SPAN.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.38759	-0.51748	-0.43636	-0.08111	0.04877
0.15	-0.36870	-0.51270	-0.41739	-0.09530	0.04870
0.20	-0.35158	-0.50821	-0.40000	-0.10821	0.04842
0.25	-0.33600	-0.50400	-0.38400	-0.12000	0.04800
0.30	-0.32176	-0.50004	-0.36923	-0.13081	0.04747
0.40	-0.29665	-0.49282	-0.34286	-0.14996	0.04621
0.50	-0.27520	-0.48640	-0.32000	-0.16640	0.04480
0.60	-0.25667	-0.48067	-0.30000	-0.18067	0.04333
0.70	-0.24049	-0.47552	-0.28235	-0.19317	0.04187
0.80	-0.22624	-0.47088	-0.26667	-0.20422	0.04043
0.90	-0.21359	-0.46668	-0.25263	-0.21405	0.03904
1.00	-0.20229	-0.46286	-0.24000	-0.22286	0.03771
1.25	-0.17867	-0.45467	-0.21333	-0.24133	0.03467
1.50	-0.16000	-0.44800	-0.19200	-0.25600	0.03200
1.75	-0.14487	-0.44247	-0.17455	-0.26793	0.02967
2.00	-0.13236	-0.43782	-0.16000	-0.27782	0.02764
2.25	-0.12185	-0.43385	-0.14769	-0.28615	0.02585
2.50	-0.11288	-0.43042	-0.13714	-0.29327	0.02426
3.00	-0.09840	-0.42480	-0.12000	-0.30480	0.02160
3.50	-0.08722	-0.4203[illegible]	-0.10667	-0.31373	0.01945
4.00	-0.07832	-0.41684	-0.09600	-0.32084	0.01768
5.00	-0.06504	-0.41148	-0.08000	-0.33143	0.01496

MULTIPLICATOR = WL/4
(λ = 0.60)

TABLE 18

BENDING MOMENT DUE TO A RISE IN THE TEMPERATURE OF THE FRAME FIBERS.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-35.29416	17.64709	-0.00003	17.64711	-35.29414
0.15	-22.22221	11.11113	-0.00000	11.11113	-22.22221
0.20	-15.78948	7.89474	0.00000	7.89474	-15.78948
0.25	-12.00002	6.00000	-0.00002	6.00002	-12.00000
0.30	-9.52382	4.76191	-0.00000	4.76192	-9.52382
0.40	-6.52174	3.26087	-0.00001	3.26088	-6.52173
0.50	-4.80000	2.40000	-0.00000	2.40000	-4.80000
0.60	-3.70370	1.85185	-0.00000	1.85185	-3.70370
0.70	-2.95567	1.47783	-0.00000	1.47783	-2.95567
0.80	-2.41936	1.20968	0.00000	1.20968	-2.41936
0.90	-2.02020	1.01010	-0.00000	1.01010	-2.02020
1.00	-1.71428	0.85714	-0.00000	0.85714	-1.71428
1.25	-1.20000	0.60000	-0.00000	0.60000	-1.20000
1.50	-0.88889	0.44444	-0.00000	0.44444	-0.88889
1.75	-0.68571	0.34286	-0.00000	0.34286	-0.68571
2.00	-0.54545	0.27273	-0.00000	0.27273	-0.54545
2.25	-0.44444	0.22222	-0.00000	0.22222	-0.44444
2.50	-0.36923	0.18462	-0.00000	0.18462	-0.36923
3.00	-0.26667	0.13333	-0.00000	0.13333	-0.26667
3.50	-0.20168	0.10084	-0.00000	0.10084	-0.20168
4.00	-0.15789	0.07895	-0.00000	0.07895	-0.15789
5.00	-0.10435	0.05217	-0.00000	0.05217	-0.10435

MULTIPLICATOR = $\gamma t L^2$

TABLE 19

RATIO BETWEEN THE MOMENT CAUSED BY DISTRIBUTED LOAD ON THE GIRDER AND THE MOMENT DUE TO PRESTRESSING OF A PARABOLIC CABLE IN EACH SPAN.

Y	K	K	K	K	K
0.10	-0.62500	-1.33333	0.00000	-1.33333	-0.62500
0.15	-0.71429	-1.18181	0.00000	-1.18182	-0.71429
0.20	-0.76923	-1.12000	0.00000	-1.12000	-0.76923
0.25	-0.80645	-1.08696	0.00000	-1.08696	-0.80645
0.30	-0.83334	-1.06667	0.00000	-1.06667	-0.83334
0.40	-0.86957	-1.04348	0.00000	-1.04348	-0.86957
0.50	-0.89286	-1.03093	0.00000	-1.03093	-0.89286
0.60	-0.90909	-1.02325	0.00000	-1.02326	-0.90909
0.70	-0.92105	-1.01818	0.00000	-1.01818	-0.92105
0.80	-0.93023	-1.01463	0.00000	-1.01463	-0.93023
0.90	-0.93750	-1.01205	0.00000	-1.01205	-0.93750
1.00	-0.94340	-1.01010	0.00000	-1.01010	-0.94340
1.25	-0.95420	-1.00690	0.00000	-1.00690	-0.95420
1.50	-0.96154	-1.00502	0.00000	-1.00502	-0.96154
1.75	-0.96685	-1.00382	0.00000	-1.00382	-0.96685
2.00	-0.97087	-1.00301	0.00000	-1.00301	-0.97087
2.25	-0.97402	-1.00243	0.00000	-1.00243	-0.97402
2.50	-0.97656	-1.00200	0.00000	-1.00200	-0.97656
3.00	-0.98039	-1.00143	0.00000	-1.00143	-0.98039
3.50	-0.98315	-1.00107	0.00000	-1.00107	-0.98315
4.00	-0.98522	-1.00083	0.00000	-1.00083	-0.98522
5.00	-0.98814	-1.00054	0.00000	-1.00055	-0.98814

TABLE 20

RATIO BETWEEN THE MOMENT CAUSED BY DISTRIBUTED LOAD ON THE FIRST SPAN AND THE MOMENT DUE TO PRESTRESSING OF A PARABOLIC CABLE IN THE FIRST SPAN.

Y	K	K	K	K	K
0.10	-0.72905	-1.06977	-0.86956	0.59574	0.07299
0.15	-0.80205	-1.04255	-0.90909	5.36335	0.17241
0.20	-0.84427	-1.02970	-0.93023	-2.98795	0.33613
0.25	-0.87177	-1.02230	-0.94340	-1.73797	0.60975
0.30	-0.89109	-1.01754	-0.95238	-1.41667	1.11103
0.40	-0.91643	-1.01186	-0.96386	-1.19717	6.95596
0.50	-0.93229	-1.00865	-0.97087	-1.11732	-4.54555
0.60	-0.94313	-1.00662	-0.97561	-1.07837	-2.35295
0.70	-0.95102	-1.00525	-0.97902	-1.05623	-1.80812
0.80	-0.95700	-1.00428	-0.98160	-1.04238	-1.56479
0.90	-0.96169	-1.00356	-0.98361	-1.03311	-1.42857
1.00	-0.96547	-1.00301	-0.98522	-1.02660	-1.34228
1.25	-0.97231	-1.00209	-0.98814	-1.01679	-1.22309
1.50	-0.97691	-1.00154	-0.99010	-1.01156	-1.16279
1.75	-0.98020	-1.00118	-0.99150	-1.00844	-1.12695
2.00	-0.98268	-1.00094	-0.99256	-1.00644	-1.10345
2.25	-0.98461	-1.00076	-0.99338	-1.00507	-1.08696
2.50	-0.98615	-1.00063	-0.99404	-1.00410	-1.07481
3.00	-0.98847	-1.00045	-0.99502	-1.00283	-1.05820
3.50	-0.99012	-1.00034	-0.99573	-1.00208	-1.04746
4.00	-0.99136	-1.00027	-0.99626	-1.00159	-1.03997
5.00	-0.99310	-1.00018	-0.99701	-1.00101	-1.03029

TABLE 21

PRESTRESSING MOMENT GIVING THE MOST DESIRABLE STRESS CONDITION FOR A LATERAL DISTRIBUTED EXTERNAL LOAD APPLIED AT THE EDGE COLUMN, ASSUMING $L/i = 100$ AND $i = e$.

Y	M	M	M	M	M
0.10	-0.01451	0.19325	0.58333	-0.39008	0.40216
0.15	-0.09075	0.20345	0.54710	-0.34365	0.36214
0.20	-0.12611	0.20589	0.52778	-0.32189	0.34611
0.25	-0.14546	0.20548	0.51533	-0.30986	0.33921
0.30	-0.15703	0.20382	0.50641	-0.30259	0.33656
0.40	-0.16906	0.19907	0.49405	-0.29498	0.33689
0.50	-0.17422	C.19378	0.48556	-0.29178	0.34022
0.60	-0.17634	0.18855	0.47917	-0.29062	0.34449
0.70	-0.17697	0.18355	0.47409	-0.29054	0.34894
0.80	-C.17682	0.17884	0.46991	-0.29107	0.35327
0.90	-0.17626	C.17441	0.46637	-0.29197	0.35737
1.00	-0.17548	0.17024	0.46333	-0.29310	0.36119
1.25	-0.17318	0.16079	0.45726	-0.29647	0.36956
1.50	-0.17089	0.15244	0.45267	-0.30022	0.37644
1.75	-0.16880	0.14493	0.44905	-0.30411	0.38215
2.00	-0.16694	0.13806	0.44611	-0.30805	0.38694
2.25	-0.16532	0.13166	0.44367	-0.31201	0.39101
2.50	-0.16388	C.12566	0.44162	-0.31596	0.39450
3.00	-0.16150	0.11450	0.43833	-0.32383	0.40017
3.50	-0.15961	0.10417	0.43582	-0.33165	0.40457
4.00	-0.15808	0.09442	0.43383	-0.33942	0.40808
5.00	-0.15577	0.07605	0.43089	-0.35484	0.41334

MULTIPLICATOR = P.e

TABLE 22

RATIO BETWEEN THE MOMENT CAUSED BY A LATERAL DISTRIBUTED LOAD APPLIED AT THE EDGE COLUMN AND THE MOMENT CAUSED BY THE MOST SUITABLE PRESTRESSING.

Y	K	K	K	K	K
0.10	-0.6592	-0.0494	-0.0338	-0.0260	-0.0267
0.15	-0.2327	-0.1036	-0.0805	-0.0668	-0.0687
0.20	-0.2926	-0.1787	-0.1474	-0.1274	-0.1309
0.25	-0.3903	-0.2750	-0.2345	-0.2076	-0.2134
0.30	-0.5133	-0.3930	-0.3418	-0.3072	-0.3159
0.40	-0.8269	-0.6956	-0.6169	-0.5637	-0.5801
0.50	-1.2277	-1.0894	-0.9725	-0.8949	-0.9226
0.60	-1.7154	-1.5779	-1.4087	-1.2989	-1.3426
0.70	-2.2905	-2.1641	-1.9253	-1.7743	-1.8396
0.80	-2.9536	-2.8518	-2.5222	-2.3196	-2.4133
0.90	-3.7050	-3.6443	-3.1994	-2.9336	-3.0637
1.00	-4.5455	-4.5455	-3.9568	-3.6149	-3.7904
1.25	-7.0382	-7.2997	-6.2014	-5.6058	-5.9408
1.50	-10.0943	-10.8236	-8.9470	-7.9941	-8.5670
1.75	-13.7173	-15.1914	-12.1933	-10.7645	-11.6685
2.00	-17.9095	-20.4865	-15.9402	-13.9028	-15.2451
2.25	-22.6731	-26.8042	-20.1876	-17.3955	-19.2964
2.50	-28.0091	-34.2526	-24.9353	-21.2299	-23.8224
3.00	-40.4026	-53.0567	-35.9315	-29.8765	-34.2982
3.50	-55.0957	-78.1410	-48.9286	-39.7531	-46.6721
4.00	-72.0920	-111.1912	-63.9262	-50.7784	-60.9438
5.00	-113.0020	-211.6028	-99.9227	-75.9860	-95.1806

TABLE 23

PRESTRESSING MOMENT GIVING THE MOST DESIRABLE STRESS CONDITION FOR A LATERAL CONCENTRATED EXTERNAL LOAD APPLIED AT THE EDGE COLUMN, ASSUMING $L/i=100$ AND $i=e$

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.00193	0.19083	0.58849	-0.39766	0.40958
0.15	-0.07289	0.20007	0.55449	-0.35443	0.37261
0.20	-0.10349	0.20166	0.53722	-0.33556	0.35928
0.25	-0.11854	0.20052	0.52667	-0.32615	0.35479
0.30	-0.12621	0.19822	0.51949	-0.32127	0.35430
0.40	-0.13140	0.19238	0.51024	-0.31786	0.35836
0.50	-0.13078	0.18622	0.50444	-0.31822	0.36478
0.60	-0.12794	0.18028	0.50042	-0.32013	0.37164
0.70	-0.12427	0.17470	0.49742	-0.32272	0.37831
0.80	-0.12036	0.16950	0.49509	-0.32559	0.38455
0.90	-0.11647	0.16465	0.49322	-0.32857	0.39031
1.00	-0.11274	0.16012	0.49167	-0.33155	0.39559
1.25	-0.10432	0.14996	0.48874	-0.33878	0.40694
1.50	-0.09722	0.14111	0.48667	-0.34556	0.41611
1.75	-0.09127	0.13322	0.48511	-0.35189	0.42362
2.00	-0.08624	0.12604	0.48389	-0.35785	0.42987
2.25	-0.08195	0.11940	0.48291	-0.36350	0.43514
2.50	-0.07826	0.11320	0.48210	-0.36889	0.43964
3.00	-0.07225	0.10175	0.48083	-0.37908	0.44692
3.50	-0.06757	0.09121	0.47989	-0.38869	0.45253
4.00	-0.06384	0.08129	0.47917	-0.39787	0.45700
5.00	-0.05825	0.06271	0.47811	-0.41540	0.46364

MULTIPLICATOR = P.e

($\lambda = 0.4$)

TABLE 23.a

PRESTRESSING MOMENT GIVING THE MOST DESIRABLE STRESS CONDITION FOR A LATERAL CONCENTRATED EXTERNAL LOAD APPLIED AT THE EDGE COLUMN, ASSUMING $L/h = 100$ AND $i = e$.

Y	M_b	M_{c1}	M_{c2}	M_{c3}	M_e
0.10	-0.03300	0.19682	0.57576	-0.37894	0.39124
0.15	-0.11702	0.20844	0.53623	-0.32780	0.34674
0.20	-0.15937	0.21210	0.51389	-0.30179	0.32674
0.25	-0.18504	0.21277	0.49867	-0.28590	0.31629
0.30	-0.20236	0.21207	0.48718	-0.27511	0.31046
0.40	-0.22445	0.20890	0.47024	-0.26134	0.30532
0.50	-0.23811	0.20489	0.45778	-0.25289	0.30411
0.60	-0.24752	0.20070	0.44792	-0.24722	0.30456
0.70	-0.25447	0.19657	0.43978	-0.24321	0.30575
0.80	-0.25985	0.19258	0.43287	-0.24029	0.30727
0.90	-0.26418	0.18876	0.42690	-0.23814	0.30892
1.00	-0.26774	0.18512	0.42167	-0.23655	0.31060
1.25	-0.27446	0.17670	0.41096	-0.23426	0.31458
1.50	-0.27922	0.16911	0.40267	-0.23356	0.31811
1.75	-0.28281	0.16217	0.39602	-0.23385	0.32117
2.00	-0.28563	0.15573	0.39056	-0.23482	0.32381
2.25	-0.28791	0.14969	0.38598	-0.23629	0.32611
2.50	-0.28980	0.14397	0.38210	-0.23812	0.32811
3.00	-0.29275	0.13325	0.37583	-0.24258	0.33142
3.50	-0.29496	0.12323	0.37101	-0.24777	0.33404
4.00	-0.29668	0.11371	0.36717	-0.25345	0.33615
5.00	-0.29919	0.09568	0.36144	-0.26577	0.33936

MULTIPLICATOR = P.e

($\lambda = 1.0$)

TABLE 24

RATIO BETWEEN THE MOMENT CAUSED BY A LATERAL CONCENTRATED LOAD APPLIED AT THE EDGE COLUMN AND THE MOMENT CAUSED BY THE MOST SUITABLE PRESTRESSING.

Y	K	K	K	K	K
0.10	-18.7530	-0.1982	-0.1353	-0.1051	-0.1078
0.15	-0.7136	-0.2768	-0.2149	-0.1800	-0.1847
0.20	-0.6432	-0.3581	-0.2952	-0.2574	-0.2640
0.25	-0.6754	-0.4410	-0.3757	-0.3355	-0.3441
0.30	-0.7343	-0.5253	-0.4563	-0.4137	-0.4241
0.40	-0.8804	-0.6975	-0.6176	-0.5692	-0.5837
0.50	-1.0427	-0.8745	-0.7789	-0.7229	-0.7422
0.60	-1.2131	-1.0561	-0.9400	-0.8746	-0.8998
0.70	-1.3890	-1.2426	-1.1011	-1.0245	-1.0565
0.80	-1.5691	-1.4339	-1.2620	-1.1726	-1.2126
0.90	-1.7528	-1.6303	-1.4229	-1.3190	-1.3682
1.00	-1.9396	-1.8320	-1.5837	-1.4638	-1.5234
1.25	-2.4187	-2.3601	-1.9854	-1.8196	-1.9101
1.50	-2.9129	-2.9254	-2.3868	-2.1669	-2.2955
1.75	-3.4203	-3.5315	-2.7880	-2.5066	-2.6801
2.00	-3.9393	-4.1829	-3.1890	-2.8389	-3.0641
2.25	-4.4690	-4.8648	-3.5898	-3.1644	-3.4477
2.50	-5.0083	-5.6433	-3.9905	-3.4833	-3.8309
3.00	-6.1122	-7.3592	-4.7917	-4.1025	-4.5968
3.50	-7.2455	-9.4037	-5.5926	-4.6983	-5.3622
4.00	-8.4038	-11.8809	-6.3933	-5.2721	-6.1271
5.00	-10.7816	-18.8284	-7.9944	-6.3590	-7.6563

(λ = 0.4)

TABLE 24.a

RATIO BETWEEN THE MOMENT CAUSED BY A LATERAL CONCENTRATED LOAD APPLIED AT THE EDGE COLUMN AND THE MOMENT CAUSED BY THE MOST SUITABLE PRESTRESSING.

Y	K	K	K	K	K
0.10	-3.1219	-0.4927	-0.3368	-0.2559	-0.2633
0.15	-1.3375	-0.6884	-0.5351	-0.4377	-0.4514
0.20	-1.3247	-0.8906	-0.7351	-0.6259	-0.6461
0.25	-1.4411	-1.0966	-0.9358	-0.8161	-0.8431
0.30	-1.5965	-1.3058	-1.1368	-1.0066	-1.0406
0.40	-1.9519	-1.7324	-1.5392	-1.3848	-1.4349
0.50	-2.3332	-2.1692	-1.9417	-1.7575	-1.8268
0.60	-2.7270	-2.6159	-2.3442	-2.1236	-2.2163
0.70	-3.1284	-3.0723	-2.7465	-2.4831	-2.6037
0.80	-3.5347	-3.5387	-3.1487	-2.8361	-2.9892
0.90	-3.9447	-4.0150	-3.5507	-3.1826	-3.3733
1.00	-4.3575	-4.5016	-3.9526	-3.5229	-3.7562
1.25	-5.3979	-5.7641	-4.9567	-4.3478	-4.7094
1.50	-6.4465	-7.0959	-5.9603	-5.1380	-5.6584
1.75	-7.5004	-8.5022	-6.9633	-5.8961	-6.6046
2.00	-8.5580	-9.9887	-7.9659	-6.6244	-7.5489
2.25	-9.6183	-11.5621	-8.9681	-7.3248	-8.4918
2.50	-10.6807	-13.2302	-9.9701	-7.9990	-9.4336
3.00	-12.8096	-16.8855	-11.9734	-9.2752	-11.3151
3.50	-14.9424	-21.0380	-13.9760	-10.4636	-13.1944
4.00	-17.0779	-25.7955	-15.9782	-11.5735	-15.0725
5.00	-21.3539	-37.7421	-19.9816	-13.5876	-18.8260

(λ= 1.0)

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REFERENCES

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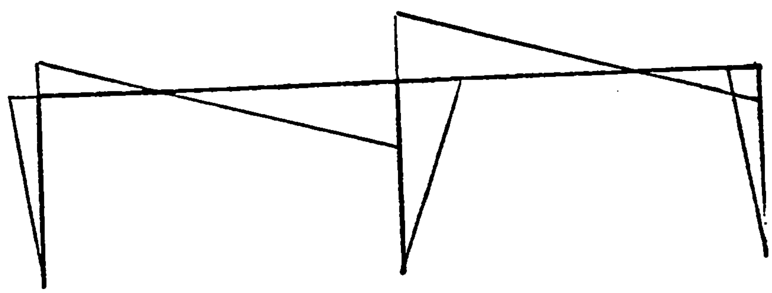
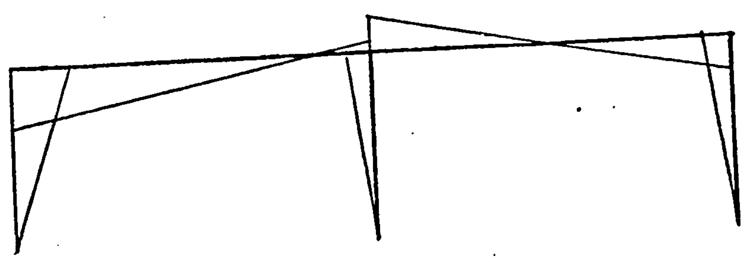
APPENDIX

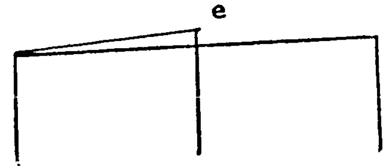
Prestressing Moment for Different Cable Profiles



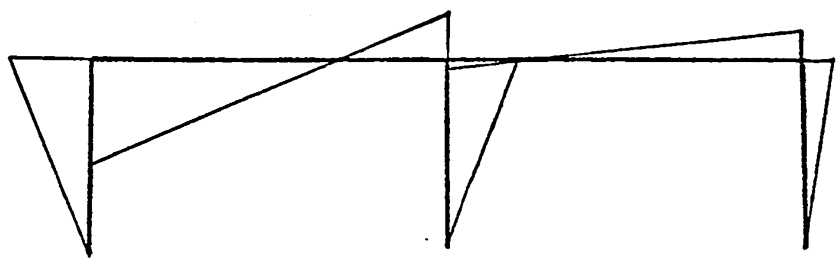
$Mo + M_M$ Diagram (1" = Pe)



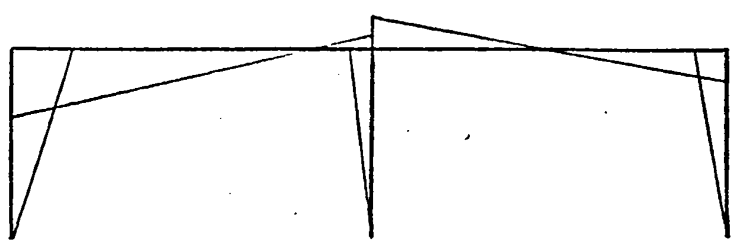
M_N Diagram (1" = 10 Pi^2/L)



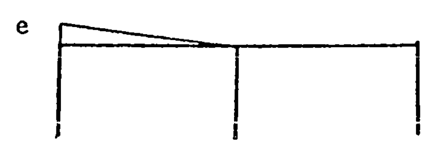
Cable Profile



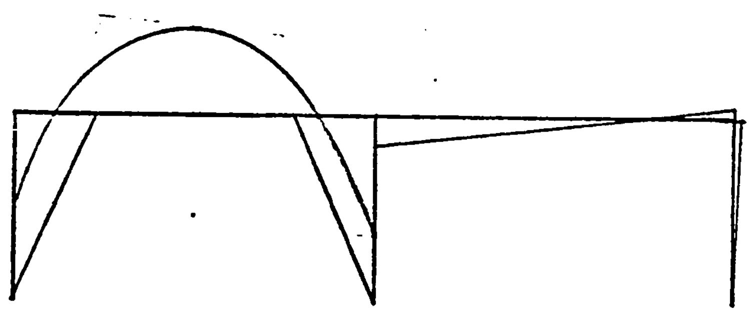
Mo + M_M Diagram (1" = Pe)



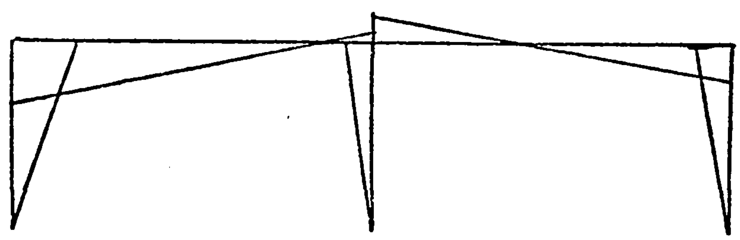
M_N Diagram (1" = 10 Pi^2/L)



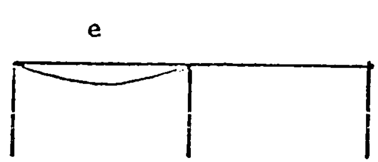
Cable Profile



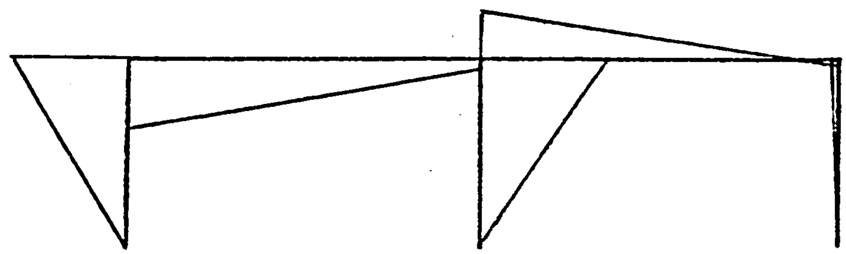
Mo + M_M Diagram (1" = Pe)



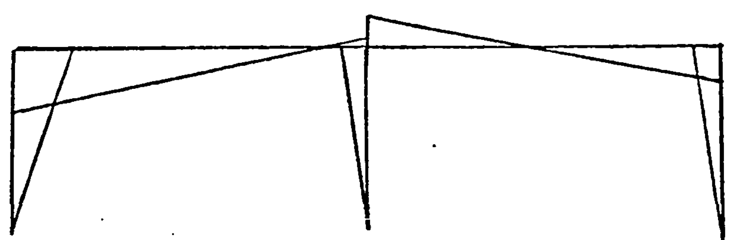
M_N Diagram (1" = 10 Pi^2/L



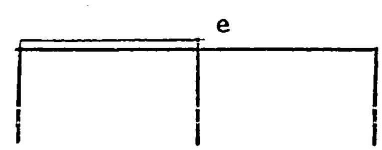
Cable Profile



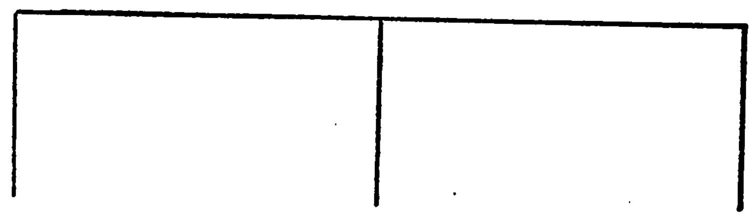
Mo + M_M Diagram (1" = Pe)



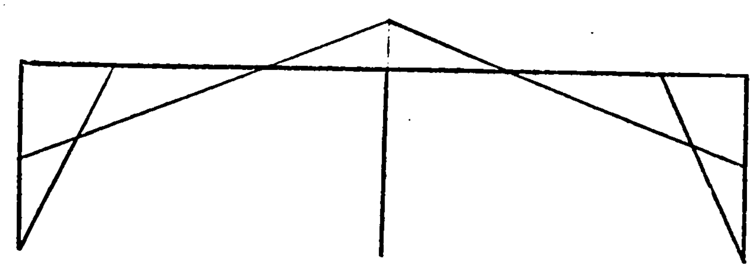
M_N Diagram (1" = 10 Pi^2/L)



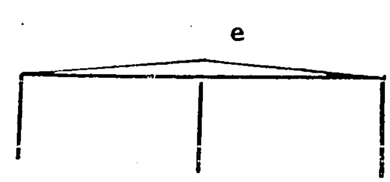
Cable Profile



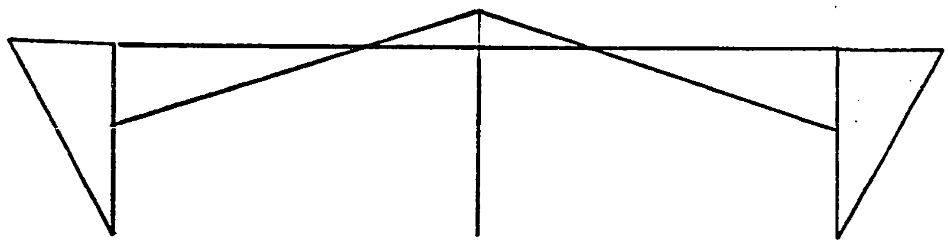
$M_o + M_M$ Diagram (= zero)



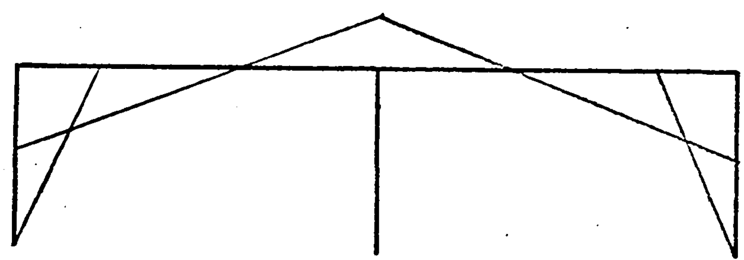
M_N Diagram (1" = 10 Pi^2/L)



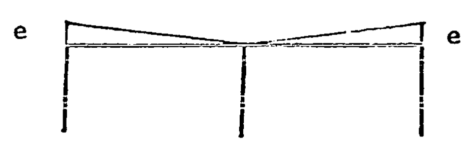
Cable Profile



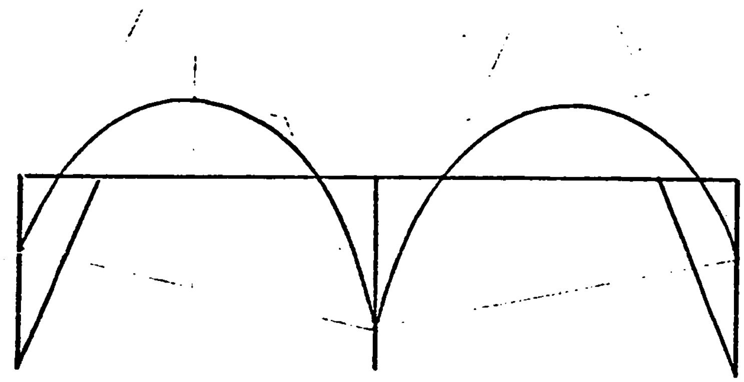
Mo + M_M Diagram (1" Pe)



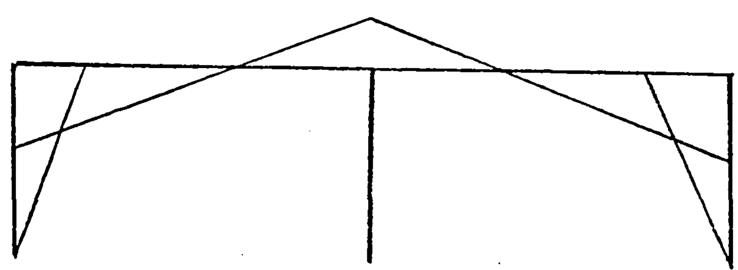
M_N Diagram (1" = 10 Pi^2/L)



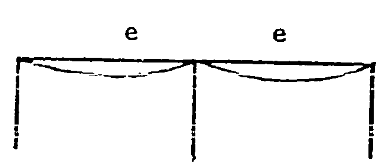
Cable Profile

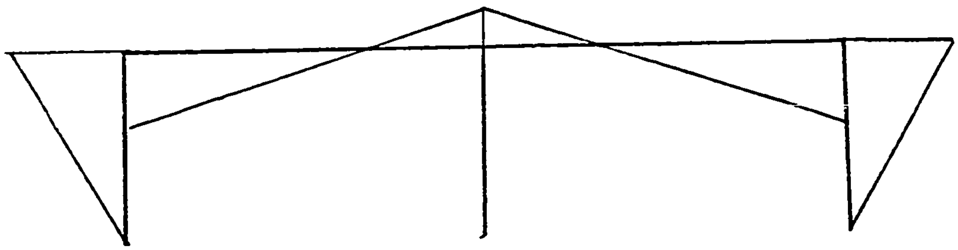


Mo + M_M Diagram (1" = Pe)

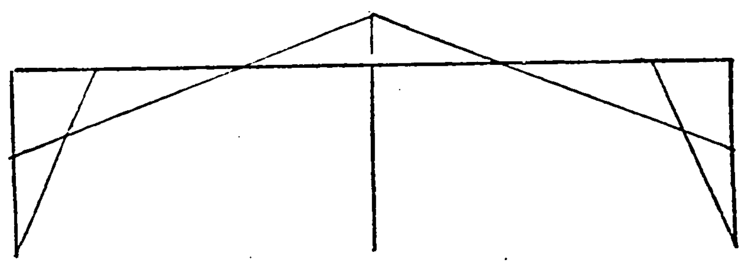


M_N Diagram (1" = 10 Pi^2/L)

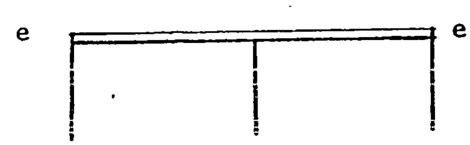




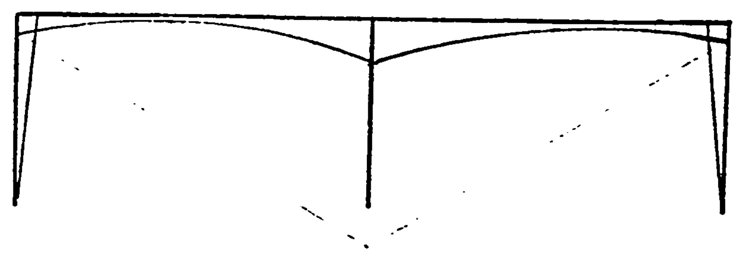
Mo + M_M Diagram (1" = Pe)



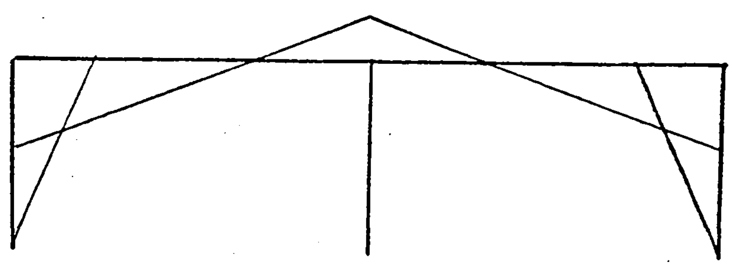
M_N Diagram (1" = 10 Pi^2/L)



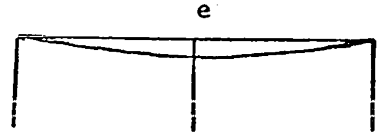
Cable Profile



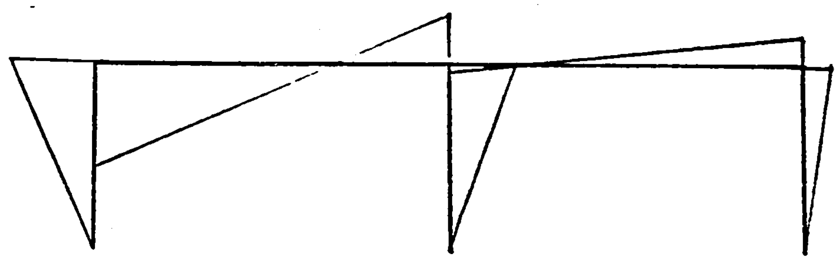
$M_o + M_M$ Diagram (1" = Pe)



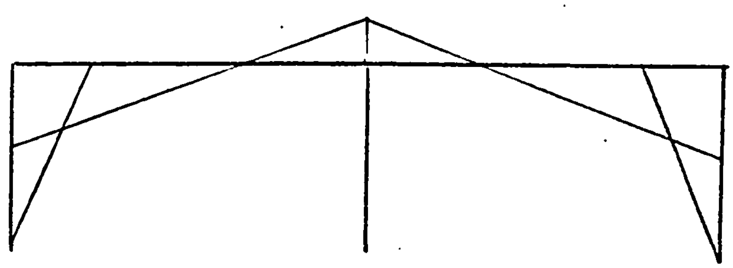
M_N Diagram (1" = 10 Pi^2/L)



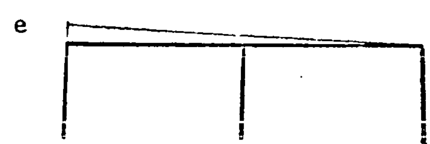
Cable Profile



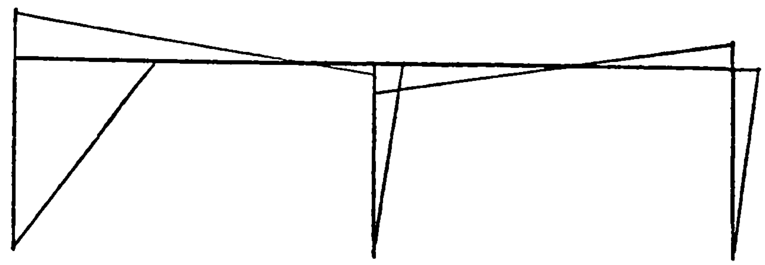
Mo + M_M Diagram (1" = Pe)



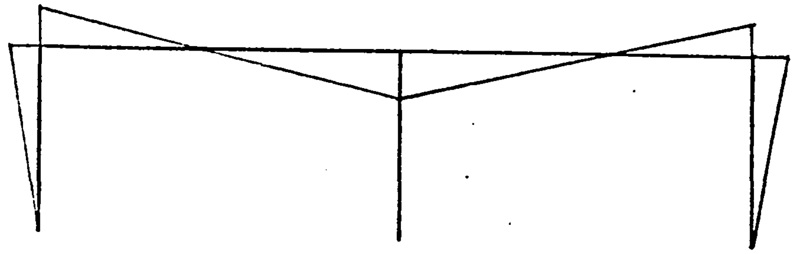
M_N Diagram (1" = 10 Pi^2/L)



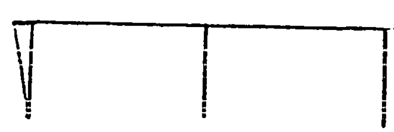
Cable Profile



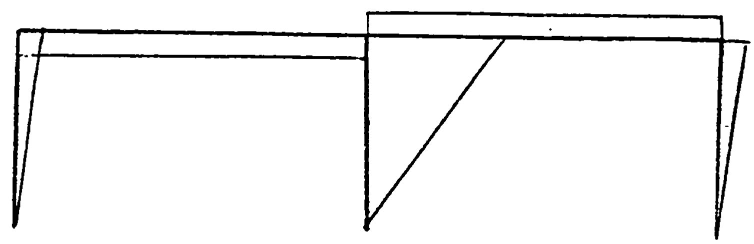
Mo + M_M Diagram (1" = Pe)



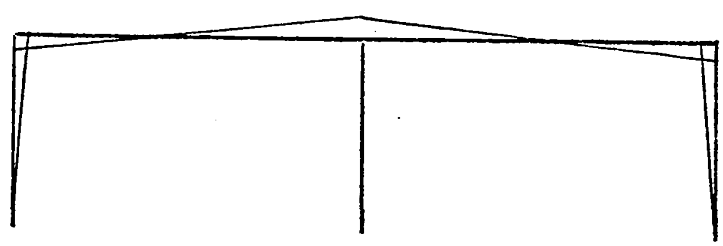
M_N Diagram (1" = 10 Pi^2/L)



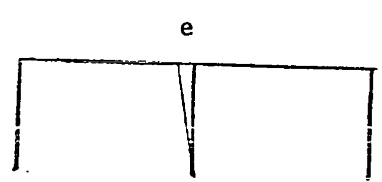
Cable Profile



$Mo + M_M$ Diagram (1" = Pe)

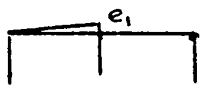
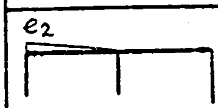
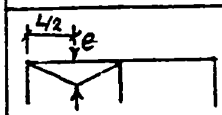
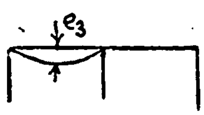
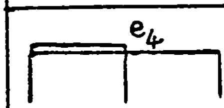
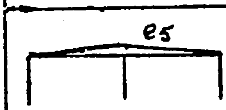
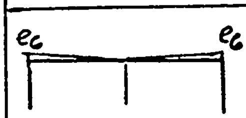
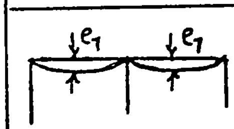
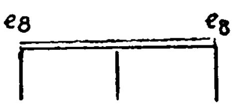
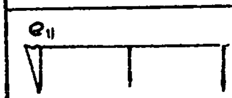
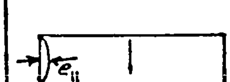
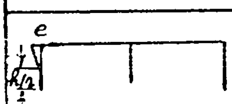
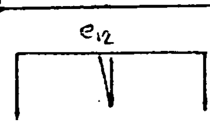


M_N Diagram (1" = 10 Pi^2/L)



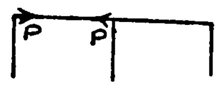
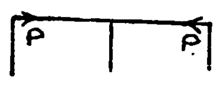
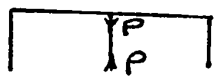
Cable Profile

Parasitic Reaction Components X_M. ($\alpha = \frac{1}{2/3y^2 + 7/6y + 1/2}$, $y = h/L$)

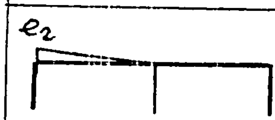
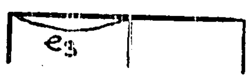
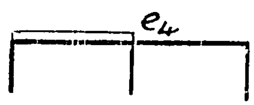
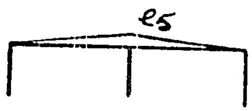
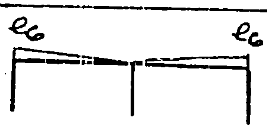
Cable Profile	X_{1M}	X_{2M}	X_{3M}
	$Pe_1\alpha(2/3y+1/2)/2yL$	$-Pe_1\alpha(1/3y+1/4)/2yL$	$-Pe_1/2L$
	$Pe_2\alpha(2/3y+1/2)/2yL$	$Pe_2\alpha(1/6y+1/4)/2yL$	$Pe_2\alpha(-1/3y^2+1/6y+1/2)/2L$
	$-Pe\alpha(2/3y+1/2)/2yL$	$-Pe\alpha/24L$	$Pe\alpha(y^2+y)/4L$
	$-2Pe_3\alpha(2/3y+1/2)/3yL$	$2Pe_3\alpha(1/12y)/3yL$	$2Pe_3\alpha(1/2y+1/2)y/3L$
	$Pe_4\alpha(4/3y+1)/2yL$	$-Pe_4\alpha(1/6y)/2yL$	$-Pe_4\alpha(y^2+y)/2L$
	-	-	$-Pe_5/L$
	-	$Pe_6\alpha(y+1)/2yL$	$Pe_6\alpha(-1/3y^2+1/6y+1/2)/L$
	-	$-2Pe_7\alpha(y/2+1/2)/3yL$	$2Pe_7\alpha(y+1)y/3L$
	-	$Pe_8\alpha(y+1)/2yL$	$-Pe_8(y^2+y)\alpha/L$
	$Pe_{11}\alpha(2/3y+1/2)/3L$	$Pe_{11}\alpha(2/3y+3/4)/3L$	$Pe_{11}\alpha(3/2y^2+3/2y)/3L$
	$Pe_{11}\alpha(2/3y+1/2)/3L$	$Pe_{11}\alpha(2/3y+3/4)/3L$	$Pe_{11}\alpha(3/2y^2+3/2y)/3L$
	$5Pe\alpha(2/3y+1/2)/24L$	$5Pe\alpha(2/3y+3/4)/24L$	$5Pe\alpha(3/2y^2+3/2y)/24L$
	$-Pe_{12}\alpha(4/3y+1)/3L$	$Pe_{12}\alpha(2/3y+1/2)/3L$	-

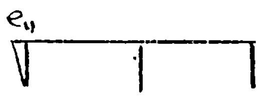
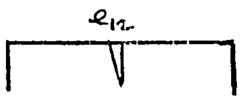
Parasitic Reaction
Components X_N

$$\alpha = \frac{1}{\tfrac{2}{3}y^2 + \tfrac{7}{6}y + \tfrac{1}{2}} \quad ; \quad y = h/L.$$

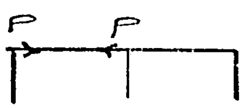
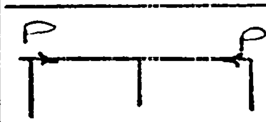
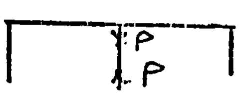
Cable Profile	X_{1N}	X_{2N}	X_{3N}
	$-\frac{P\alpha}{y^2(L/i)^2}\left\{\frac{2}{3}y+\frac{1}{2}\right\}$	$-\frac{P\alpha}{y^2(L/i)^2}\left\{\frac{2}{3}y+\frac{3}{4}\right\}$	$-\frac{P\alpha}{y(L/i)^2}\left\{\frac{3}{2}y+\frac{3}{2}\right\}$
	—	$-\frac{P\alpha}{y^2(L/i)^2}\left\{2y+2\right\}$	$-\frac{P\alpha}{y(L/i)^2}\left\{3y+3\right\}$
	—	$-\frac{3P\alpha}{2(L/i)^2}\left\{y+1\right\}$	$-\frac{P\alpha}{(L/i)^2}\left\{y^3+4y^2+3y\right\}$
	—	$\frac{3P\alpha}{(L/i)^2}\left\{y+1\right\}$	$\frac{2P\alpha y}{(L/i)^2}\left\{y^2+4y+3\right\}$

Prestressing Moment Component M_M $\qquad \alpha = \dfrac{1}{\frac{2}{3}y^2 + \frac{7}{6}y + \frac{1}{2}}$; $y = h/L$

Cable Profile	M_b	M_{c_1}	M_{c_2}	M_{c_3}	M_e
	$-\frac{1}{2} Pe_1\alpha(\frac{1}{3}y+\frac{1}{4})$	$-\frac{1}{2} Pe_1\alpha(\frac{1}{3}y+\frac{1}{4})-\frac{1}{2}Pe_1$	$-\frac{1}{2} Pe_1\alpha(\frac{2}{3}y+\frac{1}{2})$	$\frac{1}{2} Pe_1\{\alpha(\frac{1}{3}y+\frac{1}{4})-1\}$	$\frac{1}{2} Pe_1\alpha(\frac{1}{3}y+\frac{1}{4})$
	$-\frac{1}{2} Pe_2\alpha(\frac{5}{6}y+\frac{3}{4})$	$-\frac{1}{2} Pe_2\alpha(\frac{1}{3}y^2+\frac{2}{3}y+\frac{1}{4})$	$-\frac{1}{2} Pe_2\alpha(\frac{2}{3}y+\frac{1}{2})$	$-\frac{1}{2} Pe_2\alpha(\frac{1}{3}y^2-\frac{1}{4})$	$-\frac{1}{2} Pe_2\alpha(\frac{1}{6}y+\frac{1}{4})$
	$+\frac{1}{3} Pe_3\alpha(\frac{7}{6}y+1)$	$+\frac{1}{3} Pe_3\alpha(y^2+\frac{13}{6}y+1)$	$+\frac{2}{3} Pe_3\alpha(\frac{2}{3}y+\frac{1}{2})$	$+\frac{2}{3} Pe_3\alpha(\frac{1}{2}y^2+\frac{5}{12}y)$	$-\frac{2}{3} Pe_3\alpha(\frac{1}{12}y)$
	$-\frac{1}{2} Pe_4\alpha(\frac{7}{6}y+1)$	$-\frac{1}{2} Pe_4\alpha(y^2+\frac{13}{6}y+1)$	$-\frac{1}{2} Pe_4\alpha(\frac{4}{3}y+1)$	$-\frac{1}{2} Pe_4\alpha(y^2-\frac{5}{6}y)$	$\frac{1}{2} Pe_4\alpha(\frac{1}{6}y)$
	—	$-Pe_5$	—	$-Pe_5$	—
	$-\frac{1}{2} Pe_6\alpha(y+1)$	$-\frac{1}{2} Pe_6\alpha(\frac{2}{3}y^2+\frac{2}{3}y)$	—	$-\frac{1}{2} Pe_6\alpha(\frac{2}{3}y^2+\frac{2}{3}y)$	$-\frac{1}{2} Pe_6\alpha(y+1)$
	$\frac{1}{3} Pe_7\alpha(y+1)$	$\frac{2}{3} Pe_7\alpha(y^2+\frac{3}{2}y+\frac{1}{2})$	—	$\frac{2}{3} Pe_7\alpha(y^2+\frac{3}{2}y+\frac{1}{2})$	$\frac{1}{3} Pe_7\alpha(y+1)$

CABLE PROFILE	M_b	M_{c_1}	M_{c_2}	M_{c_3}	M_e
	$-\frac{1}{3}P_{e_{11}}\alpha\left(\frac{4}{3}y^2+\frac{5}{4}y\right)$	$\frac{1}{3}P_{e_{11}}\alpha\left(\frac{1}{6}y^2+\frac{1}{4}y\right)$	$-\frac{1}{3}P_{e_{11}}\alpha\left(\frac{2}{3}y^2+\frac{1}{2}y\right)$	$\frac{1}{3}P_{e_{11}}\alpha\left(\frac{5}{6}y^2+\frac{3}{4}y\right)$	$-\frac{1}{3}P_{e_{11}}\alpha\left(\frac{2}{3}y^2+\frac{3}{4}y\right)$
	$\frac{1}{3}P_{e_{12}}\alpha\left(\frac{2}{3}y^2+\frac{1}{2}y\right)$	$\frac{1}{3}P_{e_{12}}\alpha\left(\frac{2}{3}y^2+\frac{1}{2}y\right)$	$\frac{1}{3}P_{e_{12}}\alpha\left(\frac{4}{3}y^2+y\right)$	$-\frac{1}{3}P_{e_{12}}\alpha\left(\frac{2}{3}y^2+\frac{y}{2}\right)$	$-\frac{1}{3}P_{e_{12}}\alpha\left(\frac{2}{3}y^2+\frac{y}{2}\right)$

MOMENT COMPONENTS M_N

CABLE PROFILE	M_b	M_{c_1}	M_{c_2}	M_{c_3}	M_e
	$\frac{P\alpha L}{y(L/i)^2}\left\{\frac{4}{3}y+\frac{5}{4}\right\}$	$-\frac{P\alpha L}{y(L/i)^2}\left\{\frac{1}{6}y+\frac{1}{4}\right\}$	$\frac{P\alpha L}{y(L/i)^2}\left\{\frac{2}{3}y+\frac{1}{2}\right\}$	$-\frac{P\alpha L}{y(L/i)^2}\left\{\frac{5}{6}y+\frac{3}{4}\right\}$	$\frac{P\alpha L}{y(L/i)^2}\left\{\frac{2}{3}y+\frac{3}{4}\right\}$
	$\frac{P\alpha L}{y(L/i)^2}\left\{2y+2\right\}$	$-\frac{P\alpha L}{y(L/i)^2}\left\{y+1\right\}$	—	$-\frac{P\alpha L}{y(L/i)^2}\left\{y+1\right\}$	$\frac{P\alpha L}{y(L/i)^2}\left\{2y+2\right\}$
	$\frac{3P\alpha L}{2(L/i)^2}\left\{y^2+y\right\}$	$-\frac{P\alpha L}{(L/i)^2}\left\{y^3+3y^2+2y\right\}$	—	$-\frac{P\alpha L}{(L/i)^2}\left\{y^3+3y^2+2y\right\}$	$\frac{3P\alpha L}{2(L/i)^2}\left\{y^2+y\right\}$
	$\frac{-3P\alpha L\left\{y^2+y\right\}}{(L/i)^2}$	$\frac{P\alpha L}{(L/i)^2}\left\{2y^3+5y^2+3y\right\}$	—	$-\frac{P\alpha L}{(L/i)^2}\left\{y^2-5y-6\right\}$	$\frac{-3P\alpha L}{(L/i)^2}\left\{y^2+y\right\}$